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Dr. J. W. L. GLAISHER, M.A., F.R.S., PRESIDENT, in the Chair.

George Herbert Bryant, Higher Grade School, Cinderford, Gloucestershire ;
Capt. G. P. Lenox-Conyngham, R.E., Survey of India, Mussoorie, India ;
S. Alfred Mitchell, A.M., Ph.D., Columbia University, New York City, U.S.A. ;
James Rankine, 11 West Saville Road, Edinburgh ;
Thomas Thorp, Moss Bank, Whitefield, Manchester ; and
William Boultbee Whall, Nautical Surveyor, Board of Trade, Liverpool,

were balloted for and duly elected Fellows of the Society.

The following Candidate was proposed for election as a Fellow of the Society :—

Henry Bridger Adames, 5 West Street, Chichester, Sussex (proposed by W. W. Bryant).

Fifty-seven presents were announced as having been received since the last meeting, including amongst others :—

Circular No. 9 of the Astrophotographic Conference, presented by M. Lœwy ; Catalog der Astronomischen Gesellschaft, Zone $+35°$ bis $+40°$ (Lund), presented by the Astronomische Gesellschaft ; F. C. Penrose, On a method of predicting by graphical construction Occultations and Eclipses, presented by the Author ; Tachkent Observatory Publications No. 3 (W. Stratonoff, Structure de l'Univers), presented by the Observatory ; 8 charts of the photographic chart of the heavens, presented by San Fernando Observatory ; Lantern slides of Meteor, &c., presented by Professor Rees and Mr. Post ; series of astronomical drawings by the late John Brett, presented by Mrs. Brett.

On the Relative Number of Star Images Photographed in Different Parts of a Plate, and on the Performance of Various Object-Glasses in this respect. By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. If on a large number of plates taken with the same object-glass, and having a *réseau* impressed upon them, we count the number of star images in each square of the *réseau*, and add together all the results for the same square, it would be pleasant to find that the total number for each square was the same. Such a result would indicate that the object-glass covered the field under survey in an ideally uniform manner ; but in practice we can only expect an approximation to uniformity. Recently we have had occasion to examine the closeness of this approximation in the case of the object-glass used at Oxford for the Astrographic Chart photographs, and the inquiry was extended to an examination of the beautiful charts published by the French Observatories taking part in this work. The results may serve to draw attention to the general question.

2. *The Oxford Object-Glass.*—As a preliminary test of the character of the plate, the number of stars is counted before beginning measurement, and if an insufficient number of stars is found upon it another one is taken under better conditions. The counting is done by a "billiard-marker," and the number of stars in each row of 26 squares (across the plate from left to right) is entered separately. These counts were used to get a general notion of the quantities in question. Five hundred plates were taken simply in the order in which they were counted during the years 1898–1901, and the totals for the rows 0, 1, 12, 13, 24, 25 were formed for each 100. The totals for the outside rows were then expressed as percentages of the mean of rows 12 and 13, the line between these rows dividing the plato into two equal portions of 13 rows each. The results were as follows :

TABLE I.

Counts of Outside Rows of 500 *Oxford Plates expressed as Percentages of the Counts for the Middle Rows.*

No. of Group.	Rows.					
	0.	25.	Mean.	1.	24.	Mean.
I.	67	80	74	78	87	82
II.	74	81	77	83	89	86
III.	83	75	79	90	83	86
IV.	81	63	72	96	81	88
V.	88	99	94	96	99	98
Mean of 500	79	79	79	89	88	88

Thus the extreme outside rows contain 20 per cent. fewer stars than the middle rows, and the next rows within them 12 per cent. less, on the average. But the individual discrepancies are large, and Group V. is specially noticeable as being quite different from the others. No reason could be assigned at the time for the exceptional character of Group V., and a more extended investigation was undertaken. We shall presently see that, as a result of the detailed inquiry, it is possible to assign a reason for the discrepancies (see § 14).

3. For the extended investigation the *measures* of 180 plates (zone $+25°$) were tabulated. In counting the plates, as above, they are passed under review rather rapidly, and sometimes faint stars are passed over; but in measuring a plate each square is carefully examined twice at least, and such omissions should be rare.

4. In Table II. are given the total number of stars in each square of the *réseau* for the 180 plates. The total number of stars is 46,825, which gives an average of 260 per plate. If we exclude the outside rows, so as to include an area $2° \times 2°$, the total is 41,437, and the average 230. Certain features of the object-glass may be seen by inspection. The number of stars falls off rapidly near the edges of the plate, *and also near the centre*, being a maximum about $30'$ from the centre. But the accidental irregularities are still very large, even in the mean of 180 plates. To smooth these out the mean of every three adjacent numbers in x was taken, and then the mean of every three adjacent in y; so that the final result, tabulated in Table III., is the mean of a group of nine, of which the element in question forms the centre.

TABLE

Counts of Stars in each Réseau Square on 180 *Plates with*

$x=$	0	1	2	3	4	5	6	7	8	9	10	11	12
$y=$ 0	46	51	48	49	35	56	59	61	69	77	67	83	61
1	39	51	44	60	54	60	64	63	60	63	89	69	75
2	41	53	42	55	66	66	63	70	74	67	87	83	71
3	56	48	61	58	71	70	69	92	80	77	74	70	78
4	43	40	68	50	59	71	67	68	74	87	85	87	67
5	59	61	67	53	59	70	64	77	80	55	92	72	88
6	60	59	69	68	81	51	66	82	87	72	83	84	70
7	52	72	80	81	84	70	79	70	91	85	78	69	52
8	54	54	73	79	79	80	83	78	72	82	80	75	78
9	59	70	62	75	71	77	77	87	58	74	64	70	60
10	64	56	63	70	77	87	70	69	64	77	69	63	75
11	63	95	79	62	70	56	69	86	84	90	52	79	80
12	50	67	73	60	88	76	64	84	84	73	86	75	66
13	68	68	78	60	69	63	73	85	77	79	62	80	52
14	70	77	72	57	71	95	83	91	91	67	78	70	69
15	52	78	70	71	71	82	69	96	66	77	85	69	79
16	66	67	78	77	56	73	80	87	96	98	80	81	84
17	55	66	79	61	93	82	87	81	94	86	69	78	67
18	53	54	82	87	71	79	81	69	76	93	59	73	103
19	52	76	57	78	76	77	68	60	71	95	89	73	88
20	57	46	61	74	71	64	82	89	72	95	82	76	79
21	40	64	59	64	51	72	66	85	84	76	90	86	82
22	42	57	65	86	70	79	60	84	85	80	83	90	72
23	31	32	44	54	50	65	68	62	56	79	76	56	87
24	30	50	46	41	50	42	59	68	73	67	59	72	91
25	36	43	36	45	51	58	74	45	53	55	44	58	75
Mean	51	60	64	64	67	70	71	77	76	78	75	75	75

TABLE

Means of the Counts shown in Table II. over Squares of 9 *Réseau Spaces,*

$x=$	1	2	3	4	5	6	7	8	9	10	11
$y=$ 1	46	51	51	56	58	63	65	67	73	76	76
2	48	52	57	62	65	68	70	72	74	75	77
3	50	53	59	63	67	71	73	77	78	80	78
4	56	56	61	62	67	72	75	77	78	78	79

II.

Centres +25°, *taken at University Observatory, Oxford.*

13	14	15	16	17	18	19	20	21	22	23	24	25	Mean
64	69	57	60	52	61	66	52	42	51	55	39	42	57
70	68	66	75	64	48	75	65	63	63	43	40	39	60
63	56	75	60	61	54	58	65	60	56	65	36	53	62
81	74	79	69	77	59	82	80	67	74	53	38	54	69
90	67	76	72	79	79	85	51	68	77	57	59	35	68
83	89	94	56	74	75	67	72	73	76	59	70	60	71
81	94	75	80	92	74	68	63	82	74	84	61	70	74
73	64	80	66	73	75	62	71	73	70	75	72	65	72
56	88	63	55	84	67	75	71	71	69	61	80	54	72
85	58	63	65	79	82	80	70	72	83	61	79	57	71
69	76	77	86	73	77	74	74	79	72	58	69	59	71
71	84	61	80	85	56	76	82	76	85	72	71	61	74
70	73	85	70	78	84	71	63	65	70	81	62	64	72
67	87	59	84	84	74	82	100	78	75	84	64	56	73
82	67	57	55	67	88	97	77	100	72	67	71	50	75
61	79	77	69	69	79	74	86	87	98	73	75	54	75
75	66	65	66	85	84	88	85	72	73	66	70	51	76
68	72	97	96	85	76	84	79	78	72	81	77	59	78
75	78	87	74	83	93	72	76	100	69	56	68	67	76
78	83	87	89	75	72	74	72	80	59	77	54	53	74
76	83	65	73	87	74	60	66	70	72	63	61	46	71
78	60	85	82	72	73	62	62	45	60	58	65	49	68
74	88	77	77	82	71	65	66	72	54	85	51	56	72
83	72	78	64	69	63	98	62	50	47	45	36	34	60
72	79	62	73	72	70	62	52	62	44	48	40	33	58
68	72	55	74	66	61	62	48	44	36	52	32	38	53
74	75	73	72	76	72	74	70	70	67	65	59	52	69

III.

of which the Central Element is indicated by the arguments given.

12	13	14	15	16	17	18	19	20	21	22	23	24
71	66	65	65	63	60	60	60	61	58	55	50	46
73	71	70	69	69	63	64	65	68	66	60	52	47
77	73	74	70	72	68	70	68	68	66	64	57	50
80	80	82	75	75	71	75	72	72	71	67	63	54

$x=$	1	2	3	4	5	6	7	8	9	10	11
$=y$ 5	58	59	64	62	65	69	74	76	79	80	81
6	64	68	71	69	70	70	77	78	80	77	76
7	64	71	77	75	75	73	79	80	81	79	74
8	64	72	76	77	78	78	77	77	76	75	69
9	62	67	72	77	78	79	73	74	71	73	70
10	68	70	70	72	73	75	74	77	70	71	68
11	68	70	71	72	73	73	75	79	75	74	72
12	71	72	71	67	70	73	79	83	77	75	70
13	69	68	70	71	76	79	81	81	77	74	70
14	70	70	69	71	75	82	81	81	76	74	72
15	70	72	69	73	75	84	84	85	82	78	77
16	68	72	73	74	77	82	84	87	83	80	77
17	67	72	76	75	78	80	84	87	83	79	77
18	64	71	76	78	79	76	76	80	81	79	78
19	60	69	73	75	74	74	74	80	80	80	79
20	58	65	66	70	70	74	75	81	84	85	83
21	55	64	67	70	68	76	78	83	83	84	82
22	48	58	60	66	65	71	72	77	79	79	80
23	45	53	56	60	60	65	68	72	73	74	76
24	39	44	46	51	57	60	62	62	63	63	69

5. Even in the smoothed Table III. there are some irregularities. The northern half of the plate (large values of y) is richer than the southern ; but this is almost certainly due, *not* to any peculiarity of the object-glass, but to the distribution of stars in the sky. The general features of this distribution are given in a paper by Mr. Bellamy in *Monthly Notices*, vol. lx., p. 6. A glance at the middle diagram given by Mr. Bellamy (Plate 2, opposite p. 16) will show that for the rich regions 0^h—6^h and 17^h—24^h the number of stars about declination $+25°$ increases as we go north ; and for the region 6^h—17^h the distribution is indifferent. A smaller inequality in x is perhaps due to a similar cause. To eliminate this effect, and study the behaviour of the object-glass alone, we may add together squares symmetrically situated on opposite sides of the centre. Taking, for instance, the two diagonals of the plate, there are always four squares at the same distance from the centre, and the mean of the four will be free from errors of distribution in the sky, which increase uniformly in any direction. The centres of these squares will be distant 1, 3, 5, 7, &c., semidiagonals of a *réseau* square from the centre—*i.e.* $3'{\cdot}5$, $10'{\cdot}6$, $17'{\cdot}7$, $24'{\cdot}7$, and so on. Instead of giving the results separately it will be more convenient to give them alongside similar results for other object-glasses, in a comparative

12	13	14	15	16	17	18	19	20	21	22	23	24
80	81	83	78	78	76	77	70	70	71	72	69	62
75	77	81	77	77	74	74	70	70	73	74	71	69
71	73	75	74	74	74	74	69	70	71	73	72	69
68	68	70	67	70	72	75	73	72	72	71	72	67
70	72	71	70	72	74	77	74	74	74	70	70	64
73	73	72	72	74	76	75	75	76	77	73	72	65
72	74	74	77	76	75	74	73	73	74	73	71	66
71	72	73	76	76	77	76	76	77	77	76	74	68
70	70	72	71	71	76	80	82	81	78	77	72	67
70	72	71	70	69	74	79	84	87	86	82	76	66
74	74	70	67	67	73	81	84	85	83	79	74	64
74	72	73	76	79	79	81	82	81	81	78	76	67
78	77	76	78	82	82	83	82	81	78	74	70	66
78	79	81	85	86	82	79	78	80	76	75	68	66
80	82	79	80	80	80	77	73	74	74	72	64	60
79	78	77	78	79	77	72	68	66	65	65	63	58
79	74	76	77	78	77	72	67	63	63	64	63	59
78	77	77	76	76	72	73	69	65	58	58	56	53
77	80	76	74	72	71	73	68	65	56	56	50	47
73	77	71	70	68	68	69	64	60	49	47	42	40

table (Table IV.). A word of explanation may first be given as to the formation of the results for these other object-glasses.

6. *The Paris, Algiers, Toulouse, and San Fernando Object-Glasses.*—Some of the long exposure plates for the Astrographic Chart, taken at these Observatories, have recently been beautifully reproduced by heliogravure, and copies presented to the University Observatory, Oxford, among other observatories. On these copies counts of the number of stars in each square of the diagonals have been made, and the results for the four squares equidistant from the centre added together. It must be remembered that the results are not strictly comparable with those for Oxford plates, the exposures being quite different; so that the loss of stars on the paper charts depends on the increase of stellar density with magnitude near magnitude 14, while for the Oxford plates it is the density near magnitude 11, which may be quite different. It does not appear, however, that the difference is of serious importance for our present purpose. The number of charts counted varies somewhat. From San Fernando only ten charts have been received, and these were all counted. For Paris thirty charts and for Algiers twenty charts seemed to be sufficient to show the features of the distribution clearly; but in the case of Toulouse the results were rather

unexpected, and the counting was extended to forty charts for confirmation. Ultimately, as will presently be explained, the features of the different plates were all satisfactorily accounted for on a hypothesis which is at least a *possible* one. The results for the different Observatories are given in Table IV.

TABLE IV.

Total Counts of Stars in "Réseau" Squares lying along the Plate-Diagonals, for Various Observatories.

Distance of Square from Plate-Centre.	Observatory.				
	Oxford (180 plates).	Paris (30 plates).	Algiers (20 plates).	Toulouse (40 plates).	San Fernando (10 plates).
′					
3·5	255	157	133	228	68
10·6	300	154	145	228	64
17·7	308	173	131	223	66
24·7	303	166	129	248	51
31·8	335	176	148	244	59
38·9	307	214	144	247	61
46·0	276	199	177	238	42
53·0	262	195	152	190	68
60·1	223	242	135	175	46
67·2	272	220	140	153	44
74·2	206	187	128	122	42
81·3	191	155	104	110	34
88·4	162	106	78	81	31
Mean ...	262	180	134	191	52

7. In this table the relative numbers for different Observatories are of no significance at all. The charts were taken just as they came, and some are in richer regions than others. From a glance at the table we see that in no case (except possibly San Fernando) is the maximum number of stars at the centre. For Paris the maximum is even so far as 60′ from the centre, for Algiers about 45′, for Oxford and Toulouse about 30′, for San Fernando doubtful.

8. A good deal of work was done with these numbers, which, though it led up to the final result, need not be reproduced here. The accidental errors were smoothed out by various tentative processes, and the numbers reduced to percentages of (*a*) the density at the centre, or (*b*) the maximum density, and so on. But a simple hypothesis was found to fit all the facts fairly well, and may be given at once.

9. Let us suppose that the field of each object-glass is sensibly curved (fig. 1), so that if F_0 be the best focus at the

centre of the field, that at a distance r from the centre is $y = Ar^2$ nearer the object-glass than F_o. Let the plate cut the curve of best focus at Q, where

$$QM = y_o = Ar_o^2.$$

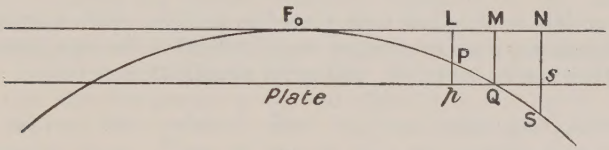


FIG. I.

Now let us suppose that if we had a curved plate F_oPQ we should get the star density uniform, and that the loss of stars is proportional to the distance of the plate from this surface. Then the density at Q will be a, say, and at P, $a - b \cdot Pp$.

But $$Pp = QM - PL = A(r_o^2 - r^2),$$

$\therefore$ density at P is $$a - Ab(r_o^2 - r^2).$$

When $r > r_o$ we must change the sign of the term in the bracket. In fact the density may be written

$$D = a\{1 \sim c(r^2 - r_o^2)\}$$

10. This hypothesis is only put forward as illustrative; the two main assumptions may be only the roughest approximations; but it seems to fit the facts tolerably well even with a constant value of c for all the five objectives; so that there is something to be said for it. To find the value of c we will take from inspection of Table IV. the following rough values of r_o and the corresponding extreme values of the density.

TABLE V.

Observatory.	r_o.	D when r is 0′.	r_o.	90′.	r_o^2.	$(90^2 - r_o^2)$.	c'_1.	c'_2.
Oxford	32′	260	335	160	1024	7076	220	74
Paris	60	157	242	100	3600	4500	98	131
Algiers	46	133	177	75	2116	5984	117	97
Toulouse ...	32	228	250	75	1024	7076	86	99
San Fernando ...	0?	68	68	31	0	8100	...	68

Since when $r = r_o$ the value of D is a, and when $r = 0$ it is $a(1 - cr_o^2)$, the difference divided by ar_o^2 gives a value of c which we may call c_1. And similarly putting $r = 90'$, and comparing with $r = r_o$, we get a value of c which we may call c_2. In the table these values multiplied by 10^6 are given under the heads c'_1 and c'_2. The mean of the values of c'_1 is 130, and of c'_2 94,

and the latter is determined from rather better divisors. We shall take as a fair assumption $c' = 100$; and thus

$$c = 100 \div 10^6 = 10^{-4}.$$

11. Hence if a plate were placed so that its *centre* was at the best focus the number of stars would fall off at various distances from the centre, as below, taking for simplicity $a = 100$:

Dist. from centre ...	0′	20′	40′	60′	80′
Number of stars ...	100	96	84	64	36

the loss being 2^2, 4^2, 6^2, &c. But if the plate be put within the focus so that the best focus is 20′ from the centre the numbers become

Dist. from centre ...	0	20′	40′	60′	80′
Number of stars ...	96	100	88	68	40

12. Having adopted a value of c it becomes possible to determine a rather more accurate value of r_0 for each Observatory. The process is as follows : Suppose we assume any value of r_0 for Oxford $> 31'{\cdot}8$ and $< 38'{\cdot}9$ (*i.e.* between the 5th and 6th values in the first column of Table IV.), say 35′. Then $acr_0^2 = r_0^2 \times 10^{-4} \times 100 = 12$.

TABLE VI.

Solution for Oxford ($cr_0^2 = 14$ *finally*).

Dist. from Centre = r.	$r^2 \times 10^{-2}$.	O_1.	O_1.	$O_1 - C_1$.	O_2.	$O_2 - C_2$.
3·5	0	88	76	−12	86	−10
10·6	1	89	89	0	87	+ 2
17·7	3	91	91	0	89	+ 2
24·7	6	94	90	− 4	92	− 2
31·8	10	98	99	+ 1	96	+ 3
38·9	15	97	91	− 6	99	− 8
46·0	21	91	82	− 9	93	−11
53·0	28	84	78	− 6	86	− 8
60·1	36	76	66	−10	78	−12
67·2	45	67	81	+14	69	+12
74·2	55	57	61	+ 4	59	+ 2
81·3	66	46	57	+11	48	+ 9
88·4	78	34	48	+14	36	+12
Mean ...		78	78	...	78	...

Forming $r^2 \times 10^{-4} \times 100$ as in the second column of Table VI., and the difference from 12, we subtract this from 100 to get C_1. The mean value of C_1 is 78 ; and the mean value of the column for Oxford in Table IV. is 262. The factor 78/262 or ·298 serves to reduce the Oxford column of Table IV. to the column O_1 of Table VI. ; and $O_1 - C_1$ shows how far we have satisfied the observations. The residuals are negative at first, positive later. Now the value of r_0 is to be adjusted. We have subtracted acr_0^2 from the first five groups in C_1, and added it to the last 8. We can improve the residuals then by increasing acr_0^2. Let us increase it by x. Then so long as x is not greater than 3 the principal effect is to diminish the first five groups by x and increase the last 8 by x. (There is a subsidiary effect arising from the change in the mean value of C_1 ; but this is small, and we may neglect it if the first approximation is good.) Hence changing the sign of the first 5 and adding to the last 8, which gives +27, we may equate this to $13x$ and get $x = +2{\cdot}3$. The effect on the mean value of C_1 is negligible, and thus $O_2 = O_1$.

13. The residuals, however, do not show much improvement, if any, and the determination of r_0 is clearly not a very exact operation. But in this way sufficiently good values of r_0 have been found for the different Observatories as follows :

Table VII.

Dist. from Centre.	Paris. $r_0 = 58''{\cdot}3$. $acr_0^2 = 34$.		Algiers. $r_0 = 49''{\cdot}0$. $acr_0^2 = 24$.		Toulouse. $r_0 = 30''{\cdot}0$. $acr_0^2 = 9$.		San Fernando. $r_0 = 34''{\cdot}6$. $acr_0^2 = 12$.	
	C	O−C	C	O−C	C	O−C	C	O−C
′ 3·5	66	+ 1	76	+2	91	+1	88	+14
10·6	67	− 1	77	+8	92	0	89	+ 8
17·7	69	+ 5	79	+2	94	−4	91	+ 9
24·7	72	− 1	82	−6	97	+3	94	−17
31·8	76	0	86	+1	99	0	98	− 9
38·9	81	+11	91	−6	94	+6	97	− 5
46·0	87	− 2	97	+7	88	+8	91	−28
53·0	94	−10	96	−6	81	−4	84	+18
60·1	98	+ 6	88	−8	73	−2	76	− 7
67·2	89	+ 5	79	+3	64	−2	67	− 1
74·2	79	+ 1	69	+6	54	−5	57	+ 6
81·3	68	− 2	58	+3	43	+1	46	+ 5
88·4	56	−11	46	0	31	+2	34	+13

Figures 2, 3, 4, and 5 illustrate these results diagrammatically.

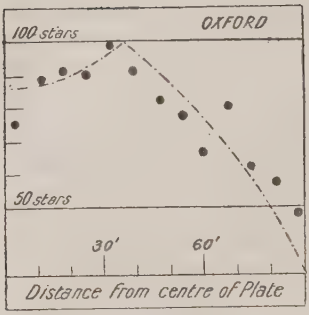


FIG. 2.

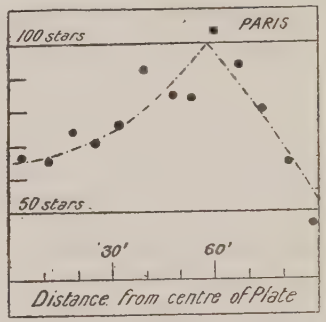


FIG. 3.

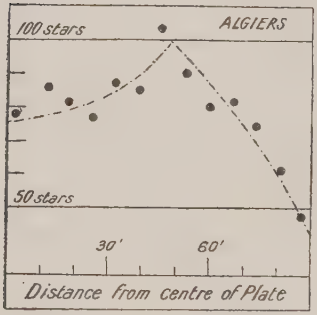


FIG. 4.

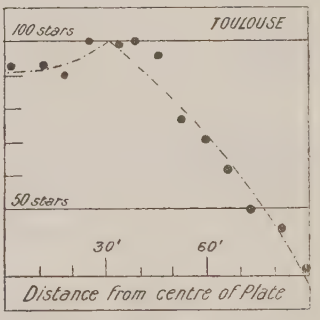


FIG 5.

14. It will be seen from the values of O—C that this rough but simple assumption fits all the facts tolerably well. And there is another observed fact which it will explain equally well. Returning to § 2, it was remarked that the counts of rows on different plates were not consistent. Group V. in Table I. is different from the other groups. Now if the performance of an object-glass be regarded as constant, and if this were the only factor involved, we might find it puzzling to explain such a change. We should have to refer it to errors of counting in some way. But on the present assumption, that apparent differences in performance of the object-glass are mainly due to different positions of the plate within the principal focus, we have an obvious method of explaining the differences in the groups of Table I. It seems probable that the plate-holder has been put back in a slightly different position, and so the outside rows, instead of being deficient compared with the central, as in the earlier groups of Table I., and as shown by the means of rows in Table II., are nearly equal to them. If this is the case our general rule tells us that the new position of the plate must be nearer the object-glass, so that the maximum falls farther from the centre than in Table II.

15. To test this the numbers for other rows of the plates in Group V. were formed ; and also for Group I., as a general check. Reduced to percentages they were found to be as follows, rows 0 and 25, 1 and 24, &c., being combined to eliminate the effect of non-uniform star distribution :

TABLE VIII.

	0 and 25	1 and 24	2 and 23	3 and 22	4 and 21	5 and 20	6 and 19	7 and 18	8 and 17	9 and 16	10 and 15	11 and 14	12 and 13
Table II.	80	85	90	100	98	102	105	105	108	107	105	108	103
Group I. of Table I.	81	86	92	100	101	103	109	106	104	104	104	104	106
Group V. of Table I.	91	94	100	102	106	104	102	106	100	102	101	98	97

In Table VIII. the first row refers to the plates in zone $+25°$ analysed in Table II. These were among the earliest plates taken and measured, and the counts are taken from the recorded measures. The second line refers to plates counted with the billiard-marker in 1898. The accordance with the first line is satisfactory, and it may be inferred that the object-glass was not sensibly disturbed up to 1898. But the third line is quite different, the maximum falling much further from the centre.

16. It must be remembered that the maximum is now *for a row* and not for a square, as formerly. Adopting the formula already given the theoretical count for a row, with any given value of r_0, is easily found ; and the following results have been obtained, reducing to percentages as before :

TABLE IX.

Value of r_0.

Values of y.	0′	15′	30′	40′	50′	60′
12 or 13	86	87	89	89	85	78
11 „ 14	85	87	89	89	86	79
10 „ 15	84	86	89	89	86	79
9 „ 16	83	85	89	89	87	80
8 „ 17	81	83	88	89	88	82
7 „ 18	78	80	87	89	89	84
6 „ 19	75	77	84	89	89	85
5 „ 20	72	72	81	87	90	86
4 „ 21	68	70	77	84	89	87
3 „ 22	63	65	72	79	88	89
2 „ 23	58	60	67	74	83	89
1 „ 24	53	55	62	69	78	88
0 „ 25	47	49	56	63	72	83
Average	72	74	79	83	85	84

17. The percentages given above are not quite similar to those we have had before, when 100 has been assigned as the mean value of a row. In counts of actual plates we had no means of knowing what the standard was; but in the above table it was supposed that the ideal number for each square (reached only at those squares on the circle of exact focus) was 100, as in Tables VI. and VII.; and we thus see that on the whole fewest stars are lost when r_0 is about 50′. At Paris the plate is rather *too* far within the focus from this point of view; at other Observatories not far enough.

18. But the chief interest of Table IX. lies in its comparison with Table VIII. We see that the first two lines of Table VIII., where the maximum is not very definite, accord very well with $r_0 = 40'$ in Table IX., as we have had independent reason to expect; but the third line in Table VIII. is much better suited by $r_0 = 50'$, or perhaps by a rather larger value than this even. Hence the supposition that the plate-holder was not put back quite into its old position seems to be confirmed.

19. It will be obvious that care must be exercised in making inferences concerning (*a*) the number of stars in a given region, (*b*) the magnitudes of stars in different parts of the plates, especially if the focal adjustments have been changed at any time. It is not proposed to dwell on the details here; rather to draw attention to the matter generally. It may be considered that the quantities discussed in this paper are not serious; but they amount to something like 50 per cent. in number of stars, or, in other words, about a whole magnitude, and I cannot but think that they must be reckoned with in any exhaustive discussion, either photometric or distributive.

20. *The C.P.D. Object-Glass.*—Let us now turn to a different sort of objective. It is remarked in the introduction to the *Cape Photographic Durchmusterung* that the field is practically uniform. As a check on the methods there explained which tend to establish this fact, the number of stars in each minute of R.A. for the zones nearest the equator were counted. The plate centres are at intervals of twenty minutes, and the totals were formed for $0^h\ 0^m$, $0^h\ 20^m$, $0^h\ 40^m$, &c., then for $0^h\ 1^m$, $0^h\ 21^m$, $0^h\ 41^m$, &c., and so on up to $0^h\ 19^m$, $0^h\ 39^m$, $0^h\ 59^m$, &c. Finally, as the effect of change of stellar density in the sky on the run of the numbers was sensible (see § 5 of this paper), the groups for 0^m and 19^m were combined, those for 1^m and 18^m, for 2^m and 17^m, and so on, and the totals reduced to percentages. The results are as follows :—

Table X.

Cape Photographic Durchmusterung.

Zone. °	0^m and 19^m	1^m and 18^m	2^m and 17^m	3^m and 16^m	4^m and 15^m	5^m and 14^m	6^m and 13^m	7^m and 12^m	8^m and 11^m	9^m and 10^m
−19	101	98	104	96	99	101	102	100	102	97
−20	108	94	93	102	105	97	103	99	105	95
−21	100	111	100	94	96	101	99	104	97	98
−22	100	100	98	102	99	100	104	104	101	90
−23	102	103	104	99	96	104	97	98	97	99

21. These numbers, which are in some ways comparable with numbers occurring in earlier paragraphs of this paper, give a high character for uniformity to the objective used for the C.P.D. The numbers in the last column in Table X. are all less than 100, and those in the first column alone never fall below 100. But beyond this bare fact the columns are distinctly comparable. We have no real discrepancies, approaching 50 per cent., such as have been discussed in the earlier paragraphs of this paper.

22. Have we been right to take the single objective, rather than the photographic doublet, for star-charting? The question has forced itself upon our attention in a number of ways since the decisive step was taken in 1887. It certainly seems, from the discussion in the present paper, that as regards getting a uniform scale of magnitudes over a large area, the doublet is immensely superior to the single objective. Over a field 2° square the latter is obviously defective; over a field 6° square the former gives excellent results. For accurate *positions* of stars the latter *may* be superior (this has yet to be established). But for charting? for the long-exposure plates, which are possibly not intended for the determination of exact positions? To take these long-exposure plates in such small areas as $2° \times 2°$ is immensely laborious; and if they are comparatively defective as well is it even yet too late to reconsider the decision of 1887?

Summary.

As a general summary of this paper the following points may be enumerated :—

A. Counts of star images on plates taken at Oxford (exposure 3^m) and at Paris, Algiers, Toulouse, and San Fernando (exposure 30^m) show that the density of stars photographed in different parts of the plate varies by about 50 per cent.

B. The region of greatest density is not the centre of the plate, but a ring which may be of 35′ (Toulouse, San Fernando, Oxford), 50′ (Algiers), or even 60′ (Paris) radius; in the last

case the density at the centre of the plate is only 0·66 of the maximum density.

C. The differences between these five Observatories may be explained on the hypothesis that the plate is put at different positions within the focus, and without assuming any essential difference in the objectives.

D. The photographic doublet used for the C.P.D. gives a sensibly uniform field over $6° \times 6°$. The question arises, have we got the best instrument for *star-charting*, seeing that it is desirable to have uniformity of magnitude over the field represented?

On Stationary Meteor Radiants. Third Paper.

By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. In *Monthly Notices*, lix. p. 140, it was suggested that the stationary character claimed for certain radiants by Mr. W. F. Denning and other observers might be explained by the cumulative effect of the Earth's attraction on members of the swarm which passed near it at successive returns. It was shown how such members might retain the direction of their velocity relative to the Earth (and therefore their radiant), and yet meet the Earth earlier in its orbit at successive returns. In this way the members of an originally compact swarm would no longer follow nearly the same orbit round the Sun, but would be distributed into a series of orbits, which might differ considerably in shape and size, but would all have two common characteristics.

(*a*) They would all intersect the Earth's orbit, though their crossing points would be distributed round it.

(*b*) When the meteors in any orbit approach their particular crossing point at the same time as the Earth they approach the Earth from the same radiant (*i.e.* with the same direction of relative velocity) as the original swarm.

2. The explanation is by no means free from objections, the most formidable of which is the great length of time required for the action to develop. The very rough quantitative estimate given in the paper was based on the assumption that the velocity or the meteors in their orbit round the Sun is usually parabolic or nearly so; for this seems to be the opinion of meteor observers, though the evidence is not of a high order of accuracy. In a second paper (*Monthly Notices*, lx. p. 450) I endeavoured to show how this might not be a fatal objection.*

* In this paper I also replied to some criticisms of M. Th. Bredikhine, who seemed to have missed the point of the suggestion. M. Bredikhine has since written a second paper (*Bull. Acad. Imp. St.-Pétersb.* Sér. V, tome xiii, No. 2), entirely shifting his ground, but in my opinion making no better case than before.

3. If it should turn out that meteoric velocities are usually sensibly smaller than parabolic it would be more favourable to this explanation; and accordingly my attention was arrested by the results of the photographic determinations of velocity made at the Yale Observatory, which indicate unexpectedly small velocities so far as they go. The account of these experiments which I have seen is a short paper by Dr. Elkin, read at the second meeting of the Astronomical and Astrophysical Society of America (reprinted from *Science*, N.S., xii. pp. 121–129). Five trails were observed, of which one was an *Andromedid*, and was presumably moving in the track of Biela's comet. The observed relative velocities were *not* parabolic, as is seen by the following comparison:

Meteor No.	1	2	3	4	5
Observed *Relative* Velocity (km. per sec.)	49·1	5·0	49·0	16·8	34·7
Theoretical Value	58·3	27·1	60·3	19·6	49·5

No. 4 is the *Andromedid*, and the theoretical velocity is calculated from the orbit of Biela's comet, the others for sensibly parabolic orbits.

4. Dr. Elkin's criticism of these results is:—"The observed velocities lead to orbits of a very improbable character having periods of from 1·25 to 1·80 years, so that it would seem an almost certain conclusion that the atmospheric retardation has amounted to from eight to fifteen km. per sec. for the four meteors."

5. Now, firstly, without laying too much stress on these few observations, I would ask, *Why* are orbits of 1·25 to 1·80 years' period of a "very improbable character"? Merely because of the novelty of the idea? To me it seems, on the other hand, more in harmony with the general habits of the solar system that many of the meteors we encounter should be revolving round the Sun in nearly circular orbits, in which case they would have just such periods.

6. Secondly, if (as Dr. Elkin admits is possible) further evidence shows these smaller velocities to be "somewhere near the cosmic values," then the time required to develop a "stationary radiant" on the lines I have suggested is much shortened. In the first paper (*Monthly Notices*, lix. pp. 148, &c.) it is shown that if

T be the time spent within the Earth's sphere of influence,
e the eccentricity of the hyperbola described relative to the Earth,

and if $f = 1/(e - 1)$, then the "time-gain" may be about $f\mathrm{T}/23$.

Now, if the relative velocity of approach to the Earth is diminished, both f and T are diminished—f because the hyperbola described relative to the Earth is more curved, and e is

therefore less; and T because the meteor is moving relatively more slowly and stays longer in the sphere of influence.

7. Thus for meteors No. 1 and No. 3 of the above series of five (with relative velocity forty-nine km. per sec.) the time-gain at each return is only about one minute: and it would take at least

$$60 \times 24 \times 365 = 525,600 \text{ encounters}$$

to scatter the swarm completely round the Earth's orbit, *i.e.* certainly many million years. But for meteor No. 5 this time would be reduced approximately in the ratio $(35/49)^2 = 1/2$; and for No. 2 in the ratio $(5/49)^2 = 1/100$.

8. But it is to the suggestion of atmospheric retardation, or to an extension of this suggestion, that I wish in the present paper to draw particular attention. In its ordinary form this notion is quite familiar to meteor observers, who notice sometimes a "slowing up" of the meteors observed, doubtless due to the friction which we know to be large enough to cause their luminosity. Mr. Denning writes in a letter to me:

"In the case of certain long-pathed meteors which I have observed the process of 'slowing-up' has been most marked, and I have recorded a few meteors which almost came to a standstill at the end of their apparent flights."

9. Now, how far away from the Earth does this "slowing-up" extend? That is to say, how far does an atmosphere capable of impeding a meteor's flight, however slightly, extend? We are accustomed to think of the atmosphere as only a few hundred miles thick at most; but this notion is derived from phenomena connected with its action on light (refraction or twilight), and the effect of even the dense air close to the earth is comparatively slight in such cases. At a height where the air is so much rarefied that all twilight effects are insensible, and refraction difficult if not impossible to trace, the density is still so great as to render meteors luminous by friction: and there must be a sensible resistance to their flight far beyond this. We know of no reason why the atmosphere should not extend half-way to the Moon or farther; and considerations of the following kind are in favour of such an extension.

10. In the outer atmosphere the pressure becomes very small, and the "free path" of the gaseous molecules increases. Dr. Johnstone-Stoney has drawn attention* to the possibility of a molecule having sufficient velocity to escape entirely from the Earth's attraction. I do not find myself in agreement with his arguments in the paper quoted, but I am not here concerned with more than this one idea of escape. According to Dr. Stoney's figures, for helium to escape from the Earth's atmosphere a velocity of nine times the mean velocity of a molecule

* *Scientific Trans. of Royal Dublin Soc.* VI. series ii. "Of Atmospheres upon Planets and Satellites."

is requisite. He considers it an established fact that there is sensibly no helium in our atmosphere (recent results show that this is not the case), and concludes that a velocity of nine times the mean is reached sufficiently often to allow of all the helium escaping. From this he argues for other planets, *e.g.* that there is no water on *Mars*. But without following him further, let us consider the idea of a molecule escaping when it happens to have a velocity nine times the mean. Now, however many molecules there may be with this velocity, there must be more with velocities slightly less, say eight times the mean. What happens to these? Clearly in similar cases they will describe orbits which are very large ellipses with the Earth in one focus, just as material particles would. There must, again, be more molecules still with a velocity seven times the mean, and they would describe rather smaller ellipses, and so on. In fact we get a conception of an atmosphere extending a very long way, where the molecules cease to behave like a gas and behave more like satellites. We have scarcely data for forming even a rough guess at the probable resistance this atmosphere might offer at (say) 1000 miles from the Earth's surface to the motion of a small body like a meteor; but there does not seem anything impossible in the supposition that the effect might be sensible.

11. Assuming then that in the neighbourhood of the Earth there may be a resisting medium, however tenuous, what would be the effect on the orbit of a meteor passing near the Earth? By "reducing the Earth to rest," as before, we get the simple case of the meteor, now moving with its velocity *relative to the Earth* only, passing temporarily through a slightly resisting medium. Hence

(1) The velocity (*i.e.* relative velocity) will be slightly diminished in magnitude.

(2) It will not be altered in direction. Further,

(3) On leaving the resisting medium the meteor will, owing to the diminution of velocity, be slightly *behind* the place it would have otherwise occupied; there is a *delay*, of the same kind as the *acceleration* due to the Earth's attraction.

12. In fact these effects are almost precisely those which have been already shown (in the case of the Earth's attraction) to produce a "stationary radiant." No. 2, the constancy of the velocity in *direction* means that the radiant is unaltered; and No. 3, the slight delay, means that the meteor is encountered by the Earth slightly *later* on the next return; so that by cumulative action at successive returns some meteors might be gradually spread along the Earth's orbit, with a constant radiant.

13. There are, however, two important new features in this action of a resisting medium as compared with that of the Earth's attraction. First, the relative velocity of the meteor is diminished each time it passes through the medium, and hence will diminish continually. This is a distinct gain as compared with our former explanation of stationary radiants, for in that the relative velocity

was left unaltered in magnitude, and this is not in accordance with observed facts (see *Monthly Notices*, vol. lix. p. 146). But, secondly, when we come to calculate quantitatively the possible *amount* of spreading of the shower, due to the delay, we find it strictly limited in amount, and such as will not explain any long duration of a stationary radiant.

14. Let v be the velocity with which the meteor enters the resisting medium at any return, and $v+dv$ that with which it leaves, dv being of course negative. Let v_0 be the original velocity and T the original time spent in the medium, so that the space traversed is v_0T. The time of traversing this space with velocity v is $v_0\mathrm{T}/v$; and if the velocity v change uniformly to $v+dv$ during the traverse, the time spent will be $v_0\mathrm{T}/(v+\frac{1}{2}dv)$, so that the delay at this particular return is $-\frac{1}{2}v_0\mathrm{T}\dfrac{dv}{v^2}$. The total delay occasioned by a change from the original velocity v_0 to v_1 is thus

$$-\tfrac{1}{2}v_0\mathrm{T}\int_{v_0}^{v_1}\cdot\frac{dv}{v^2}=\tfrac{1}{2}\cdot\frac{v_0-v_1}{v_1}\cdot\mathrm{T}.$$

15. Now the factor $(v_0-v_1)/v_1$ may theoretically be made as large as we please by diminishing v_1 sufficiently; but in practice it does not seem likely that it would be large. Taking, for example, the velocities observed at Yale as in §3, the largest value of $(v_0-v_1)/v_1$ is that for meteor 2, where $v_0=27{\cdot}1$ and $v_1=5{\cdot}0$; so that $(v_0-v_1)/v_1=4{\cdot}4$. If, further, we suppose the meteor to be originally within the resisting medium for 270,000 kilometres, or 10,000 seconds, which seems an extreme supposition, we get T = 10,000 sec. = 3 hours about, so that the total "delay" is less than seven hours. For the formation of a "long-enduring" radiant this quantity (which probably represents an extreme limit in every way) is negligible.

16. Hence the effect of the resistance of the Earth's atmosphere, though it is of the same kind as that of the Earth's attraction in many respects, is not indefinitely cumulative, and is in fact limited to a total amount which is negligible. The resistance of the atmosphere cannot be the *sole* cause of a stationary radiant.

17. But it may be a *contributing* cause. Those meteors which are subjected to the possible retardation of the atmosphere by hypothesis pass near the Earth and are subject to its attraction, as before considered, and *vice versa*. In fact we must consider the effect of *both causes conjointly*. Now the latter (the Earth's attraction) alone can be responsible for any great spreading action; but in another feature the effect of the former (atmospheric resistance) is the more important, viz. in the change of relative velocity.

18. It has been shown in the earlier papers that the Earth's attraction leaves the relative velocity of the meteors unchanged. But in § 11 it has been remarked that the atmospheric retardation

continually diminishes this relative velocity. Is this the source of the difference in velocities of meteors from the same stationary radiant observed by Mr. Denning? We must first remark which meteors will be most affected: obviously those which have been subjected to the atmospheric retardation, and therefore also to the Earth's attraction, most often and most severely. From the operation of the second cause these will be meteors encountered *earliest* in the Earth's journey through the series of showers—*i.e.* the Earth should meet slow meteors first and quick ones later. Now Mr. Denning's observed rule is quite different, at any rate in form. He says: "The meteors from showers which are moving in an opposite direction to the Earth are generally much swifter than meteors travelling with the Earth." The two rules could not agree completely; but the observed facts might by chance satisfy both. To test this I wrote to Mr. Denning for some examples, asking him whether slow meteors came early in the encounter with the radiant and quick ones late. He promptly replied (1902 March 15) by some examples which do *not* fall in with the suggested rule, and the suggested explanation falls through. One or two of the examples may be given:—

Radiant 23°+44°. *G.C. xxi. γ Andromedids.*—Meteors very swift with streaks in July and August; in September rather swift; in October slow, and in November very slow.

Radiant 30°+36°. *G.C. xxv. β Triangulids.*—Meteors very swift with streak in July and August; in September rather swift; in October swift; in November and December slow and trained.

Radiant 63°+21°. *G.C. liii. ε Taurids.*—Motion very rapid in August and September; in October rapid; in November slow. The same may be said of a bordering shower of *Taurids* from a radiant of about 57° +9°.

Radiant 61°+49°. *G.C. lvi. μ Perseids.*—Very swift in July, August, September, and November.

Radiant 270°+24°. *G.C. ccv. Herculids* (97).—Meteors very swift with streak in April; slow in July and August.

Radiant 296°+1°. *G.C. ccxxx. η Aquilids.*—Meteors very swift with streak in April and May; slow and very slow in July and August.

19. It thus seems clear that no improvement in the theory already advanced is afforded by considerations of atmospheric retardation, except in the sense indicated in §§ 6 and 7—*i.e.* that the development of a long-enduring radiant may not take so long. But, as the question of atmospheric retardation arises naturally in connection with this question of the Earth's attraction, this examination of the point may as well be put on record, although the general result is negative.

General Conclusion.

In connection with a theory of stationary radiants of meteors as due to the attraction of the Earth, advanced in former papers

(*Monthly Notices*, lix. p. 140 and lx. p. 450), the question of possible atmospheric retardation of meteors passing near the Earth has been examined. This retardation is suggested by the small velocities observed by Elkin ; and if such small velocities are found to be the rule the time required to establish a long-enduring radiant on the lines already suggested is curtailed. The atmospheric retardation may also itself exercise a spreading action on the radiant of the same kind as that exercised by the Earth's attraction, but so small in amount as to be negligible, and an accompanying effect on the relative velocity is apparently not in accordance with observed facts.

Anomalous Occultation of Stars by the Moon.

By G. W. Hough.

(*Communicated by the Secretaries.*)

In the *Monthly Notices* for 1901 April Mr. R. T. A. Innes has published an article on anomalous occultations ; and subsequently a number of communications, on the same topic, by Mr. Innes and others have appeared in the Observatory.

The subject is one of considerable interest in its bearing on the discovery of double stars, due to the abnormal phenomena which may be observed.

During the past four years I have observed nearly 300 occultations with the 18½-inch refractor of the Dearborn Observatory, using a power of 190.

With this optical power any abnormal phenomena would be well seen, except for faint stars near the time of full Moon. I have noted four classes of phenomena :—

1. Instantaneous disappearance.
2. Slow disappearance.
3. Sudden change in the brightness of the star.
4. Projection of the star on the Earth-lit disc of the Moon.

For the first case, or normal disappearance, the star seems to dive under the disc of the Moon.

For the second case the motion of the star is smooth, requiring an appreciable time to disappear, viz. $0^s{\cdot}2$.

For a phenomenon of this kind I agree with Mr. Innes that the star may be a very close double, probably beyond the reach of any telescope.

For the third case, in which there is a sudden change of brightness, the star is obviously double, and in most cases will be within the reach of existing telescopes.

A number of examples, however, have been cited, of known double stars, in which the distance of the components was 1″ or more, which were seen by the observer to "disappear gradually," whereas there should have been a sudden change in brightness.

The failure to see the real phenomenon was due to insufficient optical power, as will readily appear from the observations which follow. A small telescope and low power will not exhibit the phenomenon in the same manner as an instrument of greater power.

Double stars like *Antares*, or, in fact, all double stars, in which the components are not very unequal, and the distance not less than 2″, may be seen and recorded separately by the use of optical power equal to that I have employed.

I append such examples from my list of observations :—

1898 February 23. Σ67 8·2—9·1 mag. $p = 7°$ $s = 1''·86$.
"Companion disappeared 1^s later."

1898 June 30.
α *Scorpii* 1—8. mag. $p = 271·9$ $s = 3''·13$.
"Companion disappeared $4^s·8$ earlier."

1900 January 7. Σ 67 $p = 7°$ $s = 1''·86$.
"Companion disappeared $6^s·94$ later."

In (*A.J.*) 488 I have published a list of 193 occultations. Two interesting cases of abnormal phenomena were noted.

1897 March 3. 7·5 magnitude star. "Suddenly diminished to one-half brightness before disappearance." This star was subsequently identified as Ho 247. 87·22 $p = 101·3$ $s = 0''·36$ 7·5—8 magnitude. A very close double.

(*A.J.*) 474. 1899 October 21. τ *Tauri* 4·4 magnitude. "Reappeared first as a 9th-magnitude star, and after an interval of rather more than one second it flashed out in full brightness."

This star is without doubt a double, but, owing to the closeness and inequality of the components, it is probably now beyond the reach of any telescope.

From the apparent path of the star I determined the position of the companion $p = n.p.$ $s = 0''·15$ to $0''·4$. It is probable that no abnormal phenomena would be noticed, except for an emersion occurring between 300° and 360°, position angle.

In an unpublished list of ninety-three occultations are the following :—

1901 April 27. B.D. +4°·2333 7·5 magnitude. "About one-half the light was suddenly shut off before final disappearance." The star was subsequently identified as

OΣ 218. 98·67 $p = 70·6$ $s = 1''·15$ 7·3—9·2 mag. Hω 5″.

1901 February 25. B.D. +20″·807 9· mag.

"apparently disappeared, then seen again ; the final disappearance being $3^s·8$ later."

This star was found to be

Ho 332. $p = 126°$ $s = 1''·03$ 9—9 mag.

The computed interval for the occultation of the two components was $2^{s}\cdot5$.

It would appear from theory that any double star, of which the components are approximately equal, and the distance not less than $0''\cdot1$, would exhibit abnormal phenomena when occulted, provided sufficient optical power was used for its observation.

1901 October 17. B.D.$-20°\cdot4810$ 8·7 mag.; position angle of contact 106°. "Star appeared to be on the limb two or three seconds before disappearance. Moon's age, five days."

I have on a number of occasions seen 8th and 9th magnitude stars partially buried in the limb before disappearance.

The increased size of the Moon due to irradiation may appear to retard the actual occultation of all stars when they are in contact with the luminous disc. But when a star passes on the disc, beyond the visible boundary of the limb before it disappears, some other explanation seems necessary.

The limb of the Moon is not a smooth surface, but consists of elevations and depressions. When illuminated by Earth light the limb, however, appears comparatively smooth, since the eye cannot distinguish the minute irregularities. The apparent motion of a star occulted by the Moon varies approximately between $0''\cdot3$ and $0''\cdot6$ for one second of time. It might therefore happen, taking into account the known elevations and depressions of the lunar surface, that a star could enter an opening in the limb and remain visible a number of seconds before disappearance.

That there are considerable elevations and depressions in the Moon's limb is a well established fact.

During the total eclipse of the Sun in 1869 I recorded on a chronograph, $9^{s}\cdot3$ before the true contact of the limbs, a lunar mountain, distant eight or ten degrees north of the computed contact point.*

From what has already been said it seems reasonable to infer that, under certain conditions, a star may actually advance one second of arc, or more, beyond the visible boundary of the limb before it is occulted.

According to this view the most favourable condition for the projection of a star on the disc would be when the apparent path was radial to the limb. For a very oblique approach the phenomenon should be less pronounced.

An analysis of all recorded instances of stars projected on the luminous disc of the Moon might lead to a better understanding of the subject, but it must be kept in mind that small telescopes do not show the phenomena in the same manner as large ones.

Dearborn Observatory, Evanston: 1902 *February* 10.

* *Annals of the Dudley Observatory*, vol. ii.

Saturn Visible through the Cassini Division.

By C. T. Whitmell, M.A.

In August 1899, when engaged in studying the planet *Saturn* as a view-point, I found that there would be for *Saturn* a solar transit of the Earth on 1902 July 17. Such transits occur when (the Earth being in inferior conjunction with the Sun) *Saturn* is within about 5° 25′ of heliocentric longitude of his nodes—that is, when the heliocentric latitude, N. or S., does not exceed some 14′.

On 1902 May 24, at 5^h G.M.T., *Saturn* is at his descending node in longitude 292° 50′ 8″, and is in opposition to the Sun on 1902 July 17, at 13^h G.M.T., in longitude 294° 28′ 57″ and south latitude 0° 4′ 17″·7. The conditions for a solar transit of the Earth will therefore be satisfied on July 17.

To *Saturn* the disc of the Sun will be 192″ in diameter, that of the Earth only 2″. The chord of transit, 183″ long, lies 29″ N. of the Sun's centre, and the duration of transit of the Earth's centre for *Saturn's* centre is about $11^h\ 42^m$.

It appears also that an observer, placed in Saturnian latitude about 27° south and in a suitable longitude, will be able to view, through the Cassini division, a portion of the transit.

If we assume, with Professor Barnard, the division to be 2,270 miles broad, and the thickness of the ring-system to be 50 miles, then this division will have, at right angles to the sight line, a projected meridional breadth of about 820 miles, corresponding to about one degree of arc for the observer on *Saturn*.

At the given date, July 17, the Saturnicentric declination of the Sun is diminishing, that of the Earth increasing, and about 7^h G.M.T., or only 6^h before opposition, the Sun and the Earth are equally elevated above the ring-plane, their declination being about 22° 26′ 17″ N.

We have next to consider the matter from a terrestrial standpoint. If an observer on *Saturn* is able, through the Cassini division, to see a solar transit of the Earth, it follows that a line drawn from the Sun to the Earth can pass through this rift in the rings to the surface of *Saturn*. Thus a terrestrial observer, suitably placed, will be able to view through the rift a portion of the planet's surface lit up by sunlight, which passes through the rift, and is reflected back by the planet through the rift to the observer.

The practical effect will be that, of the arc of the Cassini division crossing the planet, a small portion will appear bright instead of dark, and may almost disappear, but probably will not quite do so, because the albedo of *Saturn* is less than that of the adjacent portions of rings A and B, which bound the fissure. Hitherto there is, I believe, no record of such a phenomenon having been observed.

Taking the actual breadth of the division as 2270 miles, and the thickness of the rings as 50 miles, I estimate, as before, the effective width of the rift (at right angles to the line of sight, and measured in the direction of a Saturnian meridian) as 820 miles, when seen from an elevation of 22° 26′ 17″ above the ring-plane.

At the Earth's distance this width corresponds to an angular breadth of only 0″·20, so that the observation will be one of peculiar delicacy and difficulty.

As already pointed out, only when *Saturn* at opposition is in the neighbourhood of a node is it possible for there to be a solar transit of the Earth, and only then can the Sun and the Earth be in line with the planet through the Cassini division It happens also that when *Saturn* is near a node the elevation of both Earth and Sun is considerable, so that the gap is well open along the line of sight.

But, if at an opposition there is an appreciable difference between the Saturnicentric declinations of Earth and Sun, the area of the planet, on the line of sight through the gap, will be shadowed by the A ring if the Sun is lower, and by the B ring if the Sun is higher, than the Earth, so that the Cassini division will appear as dark where it crosses the planet, as it does where it crosses the sky.

I hope that the conditions pointed out, which rarely occur, may lead such astronomers as are favourably situated to make what may prove to be a unique observation. As the exact limits are not easily determinable, it seems desirable that the planet should be watched for a few days, about 1902 July 17, from Observatories distributed over a wide range.

Leeds: 1902 *March* 29.

On the Supposed Variability of κ *Persei and* 36 *Persei, and a Comparison of the Photographic and Visual Magnitudes of these Stars.* By W. H. Robinson.

(*Communicated by Arthur A. Rambaut, M.A., Sc.D., F.R.S., Radcliffe Observer.*)

Two of the brighter stars used for comparison of magnitude with Nova *Persei*, viz. κ *Persei* and 36 *Persei*, have been announced as New Variables in the *Astronomische Nachrichten*,* where the Nos. assigned to them are respectively 74, 1901 and '75, 1901.

As the variability of these stars seems to have been assumed on inadequate grounds, it occurred to the writer that the data

* *Ast. Nach.*, No. 3720.

afforded by his photographs * of the region of Nova *Persei*, taken in 1901 February, March, and April, would furnish some useful evidence on the subject.

The measured photographic magnitudes of the two stars have accordingly been tabulated and plotted on square-ruled paper. In addition to these, by Dr. Rambaut's permission, some visual observations of magnitude taken at the Radcliffe Observatory are included for comparison. The visual magnitudes obtained at Poppelsdorf-Bonn by Dr. P. Guthnick, and at Bonn by Professor F. Deichmüller, are also discussed.

It will be convenient to examine the data for κ *Persei* and 36 *Persei* separately.

Dr. Guthnick's series of magnitudes of κ *Persei* from which he derives variability are the following :

TABLE I.

Poppelsdorf-Bonn Visual Magnitudes of κ Persei.

G.M.T.		Mag.	Diff. from Mean.	Compar. Stars.
1901	h			
Mar. 21	7½	3·77	+0·27	ν, ρ, 38, ξ
	9	3·45	+0·59	ν
24	8	3·98	+0·06	ν
30	9	4·18	−0·14	ν
	9½	4·13	−0·09	ν
Apr. 1	10½	4·12	−0·08	ν, *l*
4	9½	4·23	−0·19	ν
	10½	4·09	−0·05	ν, σ
	11	4·13	−0·09	ν
9	8	4·12	−0·08	ν, ξ
18	8	4·22	−0·18	ν, *l*
	8½	4·22	−0·18	ν, *l*
22	8½	4·20	−0·16	ν, Arg. +43°, 818
23	9	4·22	−0·18	ν, *l*
	9½	4·27	−0·23	ν, *l*
May 18	9½	4·0(:)	+0·04	*l*
22	10	3·78	+0·26	ν
24	9½	3·71	+0·33	ν
	9½	3·81	+0·23	ν

Remarking on these results, Dr. Guthnick says :

" Die Schwankungen der Helligkeit betrugen rund $0^m·6$, die Periode scheint mindestens gleich zwei Monaten zu sein."

It should be pointed out that, of the above magnitudes, those

* Vide *Monthly Notices R.A.S.*, vol. lxii., No. 3.

which occur in March and April are entitled to much greater weight than those in May, since in the latter month the constellation of *Perseus* is very low, and corrections required for atmospheric absorption are in consequence more or less doubtful.

The results point to a maximum brightness on or near March 21, and a minimum about April 23. It happens, fortunately, that on both of these crucial dates three observers at the Radcliffe Observatory secured estimations of magnitude of the star. A reference to the means in Table II., which follows, will show that the Radcliffe observations, instead of confirming a *fall* of $0^m{\cdot}6$ between the two dates, indicate either a *rise* of $0^m{\cdot}1$, or more probably (when a small observational error is allowed for) a *constancy* of brightness.

TABLE II.

Radcliffe Visual Magnitudes of κ Persei.

G.M.T.	Mean Mag.	Number of Observers.	Diff. from Mean.
1901 Mar. 9	3·85	3	+0·16
16	4·00	2	+0·01
20	4·13	1	−0·12
21	4·08	3	−0·07
23	3·95	2	+0·06
24	4·10	1	−0·09
26	3·93	2	+0·08
27	3·96	2	+0·05
28	4·03	3	−0·02
30	4·08	3	−0·07
31	4·09	1	−0·08
Apr. 1	4·08	1	−0·07
4	4·11	1	−0·10
5	4·07	1	−0·06
8	4·00	3	+0·01
9	4·07	2	−0·06
10	3·94	1	+0·07
12	3·98	2	+0·03
13	3·96	2	+0·05
17	4·19	1	−0·18
23	3·96	3	+0·05
24	3·86	1	+0·15
May 13	3·92	1	+0·09
22*	3·87	1	+0·14

* May 22 "Very low, near meridian, *sub polo*.

The results of the Radcliffe visual observations clearly suggest the necessity for further evidence before accepting Dr. Guthnick's conclusions, and such evidence is provided in the photographs.

In the next table (III.) the photographic magnitudes of the star are exhibited (column 6). The scaled values of brightness, from three independent series of measurements, determined in the manner described in the *Monthly Notices*, vol. lxii., No. 3, are given in columns 2, 3, 4. The next two columns contain the mean scaled values and their equivalents in magnitudes. The last column shows the differences from the mean, 4·70.

The stars used for comparison were *ν*, *l*, and 30 *Persei*.

Table III.

Photographic Magnitudes of κ Persei.

G.M.T. 1901	h	Photographic Scaled Densities. 1st Series.	2nd Series.	3rd Series.	Means.	Photogr. Magn.	Diff. from Mean.
Feb. 25	8	58·5	59·5	59·5	59·2	4·69	+0·01
26	10	59·5	60	59	59·5	4·72	−0·02
28	9	59·5	59·5	57	58·7	4·66	+0·04
Mar. 5	7	56·5	57·5	58·5	57·5	4·58	+0·12
9	9	59	59·5	59·5	59·3	4·70	0·00
	9½	59	59·5	61	59·8	4·74	−0·04
16	8	59·5	59·5	60	59·7	4·73	−0·03
	9	57	59·5	60·5	59·0	4·68	+0·02
21	9½	60·5	60·5	60	60·3	4·77	−0·07
	11	58·5	57·5	60·5	58·8	4·67	+0·03
22	8	60·5	59·5	60·5	60·2	4·76	−0·06
25	8	59·5	58	57	58·2	4·62	+0·08
	11	59	58·5	56·5	58·0	4·61	+0·09
27	11	60	60·5	58	59·5	4·71	−0·01
28	9	60	59·5	59	59·5	4·71	−0·01
30	9½	59	59·5	55·5	58·0	4·61	+0·09
	10½	60	60	57·5	59·2	4·69	+0·01
Apr. 10	9	60	61	61·5	60·8	4·81	−0·11
13	9	58·5	60	59	59·2	4·69	+0·01
15	11	59	57·5	60·5	59·0	4·68	+0·02
17	9	60·5	61	61	60·8	4·81	−0·11
19	9½	60	60·5	57·5	59·3	4·70	0·00
20	9	58·5	60·5	60	59·8	4·73	−0·03

The mean photographic magnitude of *κ Persei* is 4·70, or 0·69 fainter than the mean visual magnitude, 4·01, the difference being probably attributable to the orange colour of the star.

The residuals in the last column of Table III. are too small to admit of the deduction of any law of sensible variation of the star's brightness during the period embraced in the table, viz. February 25 to April 20.

Fig. 1, given at the end of this paper, exhibits graphically the data given in Tables I., II., and III. The correction, $-0^{m}\cdot69$, referred to in the last paragraph but one, has been applied to the magnitudes from Table III., to make the photographic and visual magnitudes directly comparable.

It will be seen that the photographic and Radcliffe visual magnitudes of κ *Persei* are best represented by a constant, and not (as in the case of the observations at Poppelsdorf-Bonn) by a variable.

The magnitudes of 36 *Persei* will be next considered.

The observations at Bonn, from which Professor Deichmüller deduces variability, are given in the second column of Table IV., whilst Dr. Guthnick's and the Radcliffe magnitudes appear in the next two columns.

TABLE IV.

Visual Magnitudes of 36 *Persei.*

G.M.T. 1901.	h	Observed Magnitudes. Deichmüller.	Guthnick.	Radcliffe.	Differences from Mean. D.	G.	R.
Mar. 28	9	5·55	5·67	...	−0·25	−0·16	...
29	8	5·60	...	...	−0·30	...	...
Apr. 7	9	5·65	5·73	...	−0·35	−0·22	...
10	9	...	...	5·30	...	...	+0·09
14	9	...	...	5·35	...	...	+0·04
19	10	5·48	...	...	−0·18	...	...
20	9	...	5·58	5·40	...	−0·07	−0·01
21	$8\frac{1}{2}$	...	$5\cdot46_2$	5·30	...	+0·05	+0·09
22	9	5·40	$5\cdot42_4$	...	−0·10	+0·09	...
23	$9\frac{1}{2}$	5·36	...	...	−0·06	...	...
25	9	...	...	5·41	...	...	−0·02
May 12	10	...	...	5·55	...	...	−0·16
21	$13\frac{1}{2}$	4·98	...	...	+0·32	...	...
22	10	...	$5\cdot18_3$	...	...	+0·33	...
	14	$5\cdot06_3$	...	...	+0·24	...	...
23	$9\frac{1}{2}$	4·92	...	...	+0·38	...	...
24	13	5·01	...	...	+0·29	...	...
Means	...	5·30	5·51	5·39			

Remarking on his observations, Professor Deichmüller says: "Bei meinen Grössenbestimmungen der Nova *Persei* nach der Methode der Stufenschätzungen habe ich öfter auch 36 *Fl. Persei*

als Vergleichstern benutzt und dabei eine Veränderlichkeit desselben von $\frac{1}{2}$ Grössenclasse wahrgenommen. Der Stern scheint jetzt im Maximum zu sein ; die Beobachtungen könnten durch eine etwa zwei-monatliche Periode dargestellt werden." *

Dr. Guthnick, in the same number of the *Astronomische Nachrichten*, publishes his observations as confirming Professor Deichmüller's.

Both of these observers record an *increase* of $0^m.5$ in the star's light between April and May ; but the Radcliffe visual magnitudes tend to show a *decrease* by May 12, when the observations were secured under very favourable atmospheric conditions, the sky being noted as "exceptionally clear." The comparison stars used on the latter date were *l Persei*, 30 *Persei*, *Arg. Z.* +43° 818, and *Arg. Z.* +44° 648.

The photographic magnitudes in Table V. are the results of three independent series of measurements, and are therefore reliable.

TABLE V.

Photographic Magnitudes of 36 Persei.

G.M.T. 1901.	h	Photographic Scaled Densities. 1st Series.	2nd Series.	3rd Series.	Means.	Photogr. Magn.	Diff. from Mean.
Feb. 25	8	70·5	70·5	71	70·7	5·50	+0·03
26	10	72·5	72	72	72·2	5·60	−0·07
28	7	71	72	71	71·3	5·54	−0·01
	9	69·5	70·5	71	70·3	5·47	+0·06
Mar. 5	7	71·5	70·5	71	71·0	5·52	+0·01
9	9	70·5	70	71·5	70·7	5·50	+0·03
	$9\frac{1}{2}$	72	68	68	69·3	5·40	+0·13
16	8	72·5	74	71·5	72·7	5·64	−0·11
	9	71	74	71·5	72·2	5·60	−0·07
21	$9\frac{1}{2}$	70·5	73	72	71·8	5·58	−0·05
	11	72	74	71	72·3	5·61	−0·08
25	8	71	71·5	71·5	71·3	5·54	−0·01
	11	69·5	71	71	70·5	5·48	+0·05
26	9	71	70	71·5	70·8	5·51	+0·02
27	11	70·5	71·5	72	71·3	5·54	−0·01
28	9	70·5	71	70	70·5	5·49	+0·04
30	$9\frac{1}{2}$	70	72	70	70·7	5·50	+0·03
	$10\frac{1}{2}$	70·5	70	71·5	70·7	5·50	+0·03
Apr. 10	9	71·5	71	72	71·5	5·56	−0·03
13	9	69·5	71	71	70·5	5·48	+0·05
15	11	71·5	70	70·5	70·7	5·50	+0·03
20	9	70·5	71	70·5	70·7	5·50	+0·03

* *Ast. Nach.*, 3720.

In forming the means given in col. 5 of the preceding table, perhaps the 3rd series (col. 4) should have received the greatest weight ; for the results in this series depend upon a special set of estimations, selecting three comparison stars of suitable brightness, and situated most favourably for the determination, by the differential method, of the magnitude of the star in question. The estimations in the 3rd series will be found to be in closer accordance than those of the other two series, which are probably affected, though only in a slight degree, by differences of atmospheric absorption.

The comparison stars used in Series 1 and 2 were generally six in number, viz. *l Persei*, 30 *Persei*, *Arg. Z.*+43° 818, *Arg. Z.*+45° 811, *Arg. Z.*+44° 734, and *Arg. Z.*+42° 795 ; whilst those of Series 3 were *Arg. Z.*+45° 811, *Arg. Z.*+46° 760, and *Arg. Z.*+45° 804.

The photographic and visual magnitudes of 36 *Persei* (Tables V. and IV.) are exhibited graphically in fig. 2.

The magnitudes resulting from the photographic method are well represented in the diagram by an almost horizontal straight line, whilst the line drawn through the Radcliffe visual estimations is slightly curved, but in the direction opposite to that of the line drawn through the observations at Bonn and Poppelsdorf-Bonn. A curious feature in the latter is the fact that a rise of magnitude of both κ and 36 *Persei* occurs in May nearly simultaneously ; but (as before pointed out) the stars in the constellation of *Perseus*, during the observing hours of the month of May, were low, and especially so in the case of the observations at Poppelsdorf-Bonn. Corrections for atmospheric absorption appear to have been applied where necessary, but such corrections to observations at small altitudes are necessarily somewhat arbitrary and uncertain.

The evidence afforded by the photographs and by the Radcliffe visual observations seems to give an emphatic negative to the hypothesis of the variability of these two stars.

Radcliffe Observatory, Oxford :
1902 *March* 9.

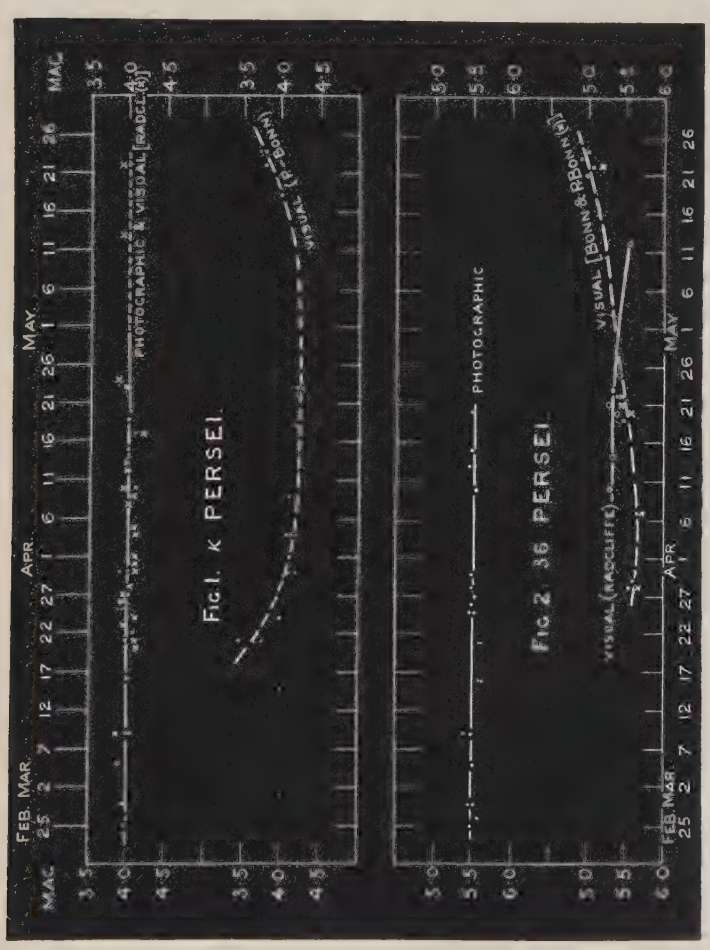
Addendum.

Further evidence—received to-day *—strongly confirms the conclusions arrived at in the present paper. The observers at Potsdam remark : " Wir haben 36 *Persei* in der Zeit von 1900 Oct. 9. bis 1902 Febr. 15. 15 mal, κ *Persei* von 1898 März 13. bis 1902 Feb. 15. 22 mal und B.D.+43° 730 von 1899 Sept. 20. bis 1902 Febr. 15. 43 mal beobachtet und bei allen drei Sternen eine

* *Ast Nach.* 3779.

so bemerkenswerthe Constanz der Helligkeit gefunden, dass ein sehr viel zwingenderes Material, als bisher veröffentlicht ist, erforderlich wäre, um uns von der Veränderlichkeit der Sterne zu überzeugen."

Radcliffe Observatory, Oxford:
1902 *March* 25.



On the Probable Motion of some of the Small Stars in the "Dumb-bell" Nebula (M 27, N.G.C. 6853). By E. E. Barnard.

In *Monthly Notices* for March 1894 (vol. liv. No. 5) Messrs. A. Rambaut and W. E. Wilson give a list of the photographic places of some of the stars in M 27, compared with the places determined by Otto Struve some forty-two years previously. These show large discordances, in many cases amounting to as much as 5″ or 6″ in the different coordinates. These discordances the authors of the above paper attribute to proper motion in these stars. Such considerable motion in so many small stars seems improbable, and if real would be of the highest interest.

In 1894 I measured several of these stars with the 36-inch at Mount Hamilton to verify the photographic results. These showed that the discordances were real. A paper on the subject was printed in *Astronomy and Astrophysics* for June 1894.

Several years ago I remeasured three of these stars and measured an additional one. I have just come across these measures and have thought it well to send them to *Monthly Notices*, where they may be properly recorded. As I think there is good reason to believe the supposed proper motions are not real, I have not thought it necessary to measure all the discordant stars mentioned by Dr Rambaut.

As usual the measures have been made in position angle and distance (double distances being measured). For comparison with the previous measures these have been reduced to $\Delta\alpha$ and $\Delta\delta$. In the reduction to $\Delta\alpha$ the measures have not been multiplied by secant of δ.

Following are the measures with the 36-inch :—

	a and q.			
	°	″	$\Delta\alpha\,(x-a)$	$\Delta\delta\,(x-a)$
1894·347	257·3	97·51		
·350	257·1	96·76		
1894·35	257·2	97·13	− 94″·72	−21″·52
	a and p.			
1894·347	43·9	83·65		
·350	43·7	83·56		
1894·35	43·8	83·60	+ 57″·86	+60″·34
	a and a'.			
1894·350	189°·5	58″·35	− 9″·63	−57″·55
	a and d.			
1894·347	84·1	154·06		
·350	83·9	154 09		
1894·35	84·0	154·07	+153″·23	+16″·10

Following are the measures with the 40-inch :—

a and *q*.

1898·358	257°·33	97″·39		
·375	257·25	97·20		
1898·37	257·29	97·29	− 94″·90	−21″·42

a and *a'*.

1898·375	189°·28	58″·32		
·394	189·60	58·52		
1898·38	189·44	58·42	− 9″·58	−57″·63

a and *d*.

1898·358	83°·85	154″·48		
·375	83·62	154·19		
1898·37	83·73	154·33	+153″·41	+16″·85

a and *i*.

1898·375	72°·24	247″·60		
·394	72·16	248·36		
1898·38	72·20	247·98	+236″·11	+75″·81

These compared with Struve's measures give the following differences, and for further comparison Wilson's measures are also given.

For the star *q*.

		Δα	Δδ	Δα	Δδ
				Differences from Struve.	
	Struve	− 97″·6	−20″·9		
	Wilson	− 94·4	−20·6	−3″·2	−0″·3
1894	Barnard	− 94·7	−21·5	−2·9	+0·6
1898	„	− 94·9	−21·4	−2·7	+0·7

For the star *a'*.

	Struve	− 12″·3	−57″·2		
	Wilson	− 9·6	−57·5	−2″·7	+0″·3
1894	Barnard	− 9·6	−57·5	−2·7	+0·3
1898	„	− 9·6	−57·6	−2·7	+0·4

		Δα	Δδ	Δα Differences from Struve.	Δδ
	For the star *p*.				
	Struve	+ 60″·6	+ 57″·9		
	Wilson	+ 56·6	+ 60·1	+ 4″·0	− 2″·2
1894	Barnard	+ 57·9	+ 60·3	+ 2·7	− 2·4
	For the star *d*.				
	Struve	+ 152″·5	+ 12″·8		
	Wilson	+ 151·5	+ 16·6	+ 1″·0	− 3″·8
1894	Barnard	+ 153·2	+ 16·1	− 0·7	− 3·3
1898	„	+ 153·4	+ 16·8	− 0·9	− 4·0
	For the star *i*.				
	Struve	+ 238″·2	+ 71″·5		
	Wilson	+ 232·9	+ 74·3	+ 5″·3	− 2″·8
1898	Barnard	+ 236·1	+ 75·8	+ 2·1	− 4·3

My measures have not been reduced to the epoch of Struve's observations.

These differences certainly imply change of some sort if the early measures can be relied on. But if we examine *Phil. Trans.* vol. 151, part iii, it will be seen that in the observations of these stars very few direct measures of distance were made, the distances being computed from the observed angles along with a few measured distances. This is an unsatisfactory method and liable to many errors. It does not therefore seem certain that these discordances are due to motion in the observed stars.

Yerkes Observatory, Williams Bay, Wisconsin:
1902 *March* 22.

Notes on Nebulæ observed at the Royal Observatory, Cape of Good Hope.

(*Communicated by Sir David Gill, K.C.B., F.R.S., H.M. Astronomer.*)

By Mr. J. Lunt.

Five new nebulæ were picked up with the 18-inch telescope during a search for Brorsen's Comet in 1900. Their positions are (1900)—

R.A. h	m	Dec. °	′
22	3·5	−47	40
22	5·2	−46	36
22	8·3	−46	24
22	15·2	−46	34
22	25·5	−46	30

These are near the nebulæ *h* 3924, *h* 3931, and *h* 3932 (N.G.C. 7213, 7232, and 7233).

New (1900) $10^h\ 56^m\ 28^s{\cdot}2$, $-64°\ 42'{\cdot}7$.

A stellar nebula found visually with the 24-inch o.g. prism. Mag. 10–11.

Immediately N.p. C.P.D. $-64°$ 1588.

Spectrum on plate 159 (12/6/1901), chart on plate 164 (14/6/1901).

New (1900) $17^h\ 49^m\ 6^s{\cdot}6$, $-21°\ 47'{\cdot}0$.

A stellar nebula found visually with the 24-inch o.g. prism. Mag. 12–13.

Immediately S.f. C.P.D. $-21°$ 6502. The nebula is $2^s{\cdot}5$ pr. a slightly brighter star of the same declination.

Photographed on plates 178 and 182 (24/6/1901 and 8/7/1901).

By Mr. R. T. A. Innes.

h 2518 (N.G.C. 1269). Not visible in the 7-inch. (3/12/1901.) This is perhaps the same as Δ487 (N.G.C. 1291), observed by *h* on the same night. *h* gives for the latter exactly the same declination and description as for *h* 2518.

Δ487 was well seen on the night that *h* 2518 could not be found.

h 3443 (N.G.C. 4815). It is doubtful if this (which *h* calls a cluster) is resolvable in the 7-inch. It is involved with, but to the S of, the two stars C.P.D. $-64°$, 2088 and 2090. Place of latter (1875), $12^h\ 50^m\ 16^s{\cdot}5$, $-64°\ 16'{\cdot}5$.

h 3546 (N.G.C. 5357). There is no nebula visible in the 7-inch in *h*'s position. There is a small elliptical nebula near two 10th mag. stars at (1860) $13^h\ 49^m{\cdot}8$, $-28°\ 38'$. This is 1° different from *h*'s declination.

New (1875) $13^h\ 28^m{\cdot}6$, $-61°\ 25'$.

This is a small round nebula about 1′ in diameter, brighter towards the centre.

h 3563 (N.G.C. 5530). As seen with the 7-inch. This is a fine nebulous star. *h* has !, vF, pmE, e s v m b M ★ 12.

Cordoba D.M. $-43°$, 9005. (1875) $14^h\ 14^m\ 30^s{\cdot}8$, $-43°\ 34'{\cdot}2$.

As seen with the 7-inch on 14/8/1901 this is a fine planetary nebula, 10 mag., about 20″ in diameter. Examined

on the same night with the 18-inch telescope, it appeared dumb-bell-shaped. Mr. Lunt, with the 24-inch o.g. prism, found the spectrum to be that of a gaseous nebula. This nebula also appears on several *Carte du Ciel* plates. Plate 3689, with 1^h exposure, shows two very elongated spindle-shaped nebulæ of the same length, parallel to each other, and in contact at their points of greatest condensation or brightness. Angle of elongation = 80°.

The different appearances shown by the different instruments is instructive.

This nebula was also found at Arequipa. See *Harvard Circular*, No. 60, received here 22/8/1901.

New (1875) $17^h\ 34^{m}\cdot8$, $-64°\ 37'$.

A faint oval nebula 1′ in diameter, N. p. η *Pavonis*. Found with the 7-inch.

Royal Observatory, Cape of Good Hope:
1902 *February* 20.

Cape Double Star Results, 1901. By R. T. A. Innes.

(*Communicated by Sir David Gill, K.C.B., F.R.S., H.M. Astronomer.*)

The year generally was unfavourable for double star work. All the measures were made with the Repsold micrometer on the 18-inch refractor. In the cases of a few newly discovered pairs estimates only have been secured: these were generally made with the 7-inch refractor.

It was found that an arithmetical error had been made in the determination of the screw-value used in the reduction of the measures made in 1900. Further observations for the determination of screw-value were also made. A perplexing difference between the value derived from slow-moving stars and from differences of declination has been brought to light. It is shown below:—

1st Method.

Differences of Declination of Stars whose Relative Positions have been Determined with the Heliometer.

Date.	Revs.	Diff. Dec.	Value.	Stars.	Heliometer.
1899 Dec. 2–3–4	14·2993	251″·63	17″·598	ζ_1 & ζ_2 Reticuli	Cape
1901 Dec. 13	20·0658	353·76	·605	19 „ 20 Tauri	Yale
„ „ 23	16·4273	288·89	·586	16 „ 20 „	„
1902 Jan. 7	82·9516	1462·28	·610	19 to 27 „	„
„ „ 8	17·0838	300·98	·618	Dist. Atlas & Pleione	„

2ND METHOD.

Transits of Polar Stars.

1901.		Dec.	Value.
Dec. 19	o Octantis	−88° 34′	17″·684
„ 23	„ „	„ „	17·673
„ 28	B.A.C. 1960	84 50	17·655

As the method of determining double star distances is akin to the 1st method described, the present series of observations has been reduced with the screw-value taken equal to

$$17''\cdot603.$$

To reduce the Cape observations of 1900 to this value they must be diminished by a $\frac{1}{210}$th part, or as follows :—

Distances.	Correction.
″ ″ 0·0 to 1·0	″ −0·00
1·1 „ 3·2	0·01
3·3 „ 5·4	0·02
5·5 „ 7·6	0·03
7·7 „ 9·8	0·04
10	0·05
20	0·09
30	0·14
40	−0·19

The cause of the discordance between the two methods for finding the screw-value seems obscure, and will be further investigated. It is noteworthy that Otto Struve found a similar discordance at Pulkowa (*Observations*, vol. ix. pp. 18 and 24), viz.

From measured distances	9″·7091.
„ transits of stars	9″·7326.

He gave his preference to the former value.

The arrangement of the measures will be easily understood. The column "Diff. Mags." is only filled in when actually observed. The colours of the double stars have been frequently recorded. For brevity's sake the following contractions have been used :—

Y = Yellow.	y = yellowish.
B = Blue.	b = bluish.
R = Red.	r = reddish.

o = White.

1–3 = Different shades of yellow.

4–6 = „ „ „ orange.

7–10 = „ „ „ red.

The measures are followed by notes. A separate list of stars examined and not seen double is added. Although some of the latter are certainly double it seemed best to give the list which completes the record of observation. A short list of errata and emendations to the Reference Catalogue of Southern Stars is also included.

[In the references to the *Cape Photographic Durchmusterung* given in the first column, the zone is omitted, as it may be inferred from the column S. Dec. Thus, No. 15, C.P.D. 214 is C.P.D.—63°, 214.]

Professor E. C. Pickering kindly sent lists of new double stars recently found at Arequipa; some of these have since been measured, and the remainder are on the working list.

The observations of *α Centauri*, by Sir David Gill and myself, are given separately. They show that the greatest distance attained is less than the predicted by about 0″·20.

The following casual observations may also be placed on record :—

Lac. 1884	1901 02	204°·5	″ ...	S. S. Hough	1n
Σ 1104	·08	332·1	2·25	J. Lunt	1
Σ 1146	·08	13·2	3·06	,,	1

Star.	Mag.	R.A. 1900 h m	S. Dec. 1900 ° ′	1901·+	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A.	B.	No. of Nights.	Remarks.
Harvard ...	5·6	0 1	49 38	90	177·4	5·65	...	...		3–2	1
,, ...	6·4	0 4	54 34	84	294·0	0·73	...	...		1	...
λ 3	8·5	0 5	34 20	94	196·3	1·09	1·0	...		1	...
Innes 43 ...	6·9	0 6	73 47	84	327·2	0·86	...	...		1	2
h 3350 ...	8·2	0 6	58 3	89	179·3	3·32	0·4	...		2	3
β Toucani ...	3·6	0 27	63 31	46	170·7	27·1	0·2	...		2	4
β_2 ,, ...	4·3	...	...	58	293·1	0·94	...	...		3–2	5
λ_1 Sculpt. ...	6·1	0 37	39 1	84	321·5	0·54	0·1	...		1	6
Harvard ...	5·7	0 41	48 6	84	304·8	14·4	...	3—		1	7
h 3396 ...	9·4	0 41	33 50	94	221·8	4·31	1·0	...		1	...
Innes 261 ...	7·2	0 43	29 53	84	55·5	...	...	...		1	8
h 3418 ...	9·0	1 2	58 26	89	253·0	2·95	...	...		2	...
Gilliss 9 ...	6·7	1 7	73 29	84	355·3	3·60	3 0	...		1	...
Innes 27 ...	7·3	1 12	69 21	46	204·1	0·95	0·6	4, 4		2–1	...
κ Toucani ...	4·9	1 12	69 24	46	351·6	5·18	...	3,—		2	9
p Eridani ...	5·3	1 36	56 42	03	221·8	7·80	0·3	3·5, 4		2	...
Gilliss 14 ...	7·2	1 39	82 47	03	54·6	5·49	1·2	...		1	...
h 3464 ...	7·8	1 40	76 45	50	158·0	3·09	1·6	...		2	...
Innes 52 ...	8·5	1 43	44 28	97	178·6	0·62	0·3	...		1	...
h 3469 ...	6·4	1 46	38 54	97	351·5	28±	7·6	...		1	10

Star.	Mag.	1900 R.A. h m	1900 S. Dec. ° ′	1901·+	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A. B.	No. of Nights.	Remarks.
Innes 265 ...	8·0	1 57	44 19	97	24·6	0·95	1·5	...	1	...
„ 311 ...	8·4	2 2	82 47	04	41·5	1·93	0·7	2·5, B	3–2	11
U.A. 13½ Horologii	7·2	2 37	59 59	06	317·5	0·25 ±	0 2	0, 0	4	12
h 3541 ...	8·5	2 50	60 20	41	156·4	2·52	1·3	2, b	2	...
C. Z. 3h 1 ...	8 0	3 1	60 23	08	146·7	0·57	0·2	Y, Y	1	13
Cape 3 ...	9·2	3 5	42 54	06	254·0	2·17	0·6	...	1	...
Innes 54 ...	8·7	3 5	41 45	06	131·1	0 74	0·3	..	1	...
λ 22	8·0	3 8	30 39	06	343·4	1·17	2·0	...	1	14
Innes 55 ...	5·9	3 9	44 48	08	182·3	0 82	0·8	3, 3	2	102
O.A. 2179 ...	8·5	3 14	19 26	08	163·0	3·86	1·5	...	2	...
C.P.D. 214 ...	8·3	3 14	63 39	09	322·2	0·66	0·4	...	1	15
Innes 150 ...	8·2	3 16	63 26	09	358·3	3·80	3·5	...	1	...
χ_3 Fornacis...	6·6	3 24	36 12	95	251·0	6·54	...	—, r	1	...
C.P.D. 570 ...	8·8	3 47	55 39	42	203·2	2·13	0·2	...	2	16
Harvard ...	5·6	3 51	40 39	06	172·8	23·1	6·6	3,—	2	...
Innes 269 ...	7·3	3 59	54 41	40	78·7	3·38	...	...	2	...
„ 152 ...	7·6	4 1	35 43	05	70·5	0·83	0·0	...	1	...
„ 271 ...	7·5	4 19	43 1	40	145·3	2·34	2·3	3·5, b	2	...
Cape 28 ...	9·1	4 34	50 21	03	279·0	6·37	0·4	...	2	...
h 3672 ...	8·3	4 35	35 30	01	300·5	4·23	1·0	—, 4	1	...
α Cæli	4·5	4 37	42 3	41	111·9	5·78	7·2	2, —	2	...
Innes 60 ...	9·0	4 38	45 54	01	95·6	2·33	0·2	...	1	...
h 3696 ...	8·4	4 46	56 11	03	290 8	3·29	0·8	...	2	17
„ AC	...	...	...	05	117·3	9 ±	5·2	...	1	
Cordoba [10]	7·5	4 46	50 3	01	256·3	4·49	3·0	...	1	18
θ Pictoris ...	6·3	5 23	52 24	97	199·3	0·43	0·2	...	1	...
Lac. [1873]	8·5	5 23	58 15	49	103·4	0·48	0·0	Y, Y	2	19
Innes 347 ...	8·0	5 36	75 18	01	129·0	9·06	4·0	...	1	...
„ 279 ...	8·5	5 43	43 18	02	9·4	0·86	0·7	...	1	...
„ 348 ...	9·0	5 49	29 3	08	60 5	4·07	2·0	...	2	20
h 3807 ...	8·3	5 49	41 42	02	273·1	5·07	2·0	4, B	1	...
Innes 16 ...	7·0	5 49	38 33	02	123·1	1·13	4·0	4, b	1	...
Dunlop 23 ...	6·9	6 2	48 27	01	40·1	1·66	0·4	...	2	...
Innes 349 ...	7·0	6 11	29 34	02	44·7	6 96	...	...	1	...
„ 3 ...	6·9	6 12	61 27	50	7·0	0·79	0·4	Y, Y	2	...
Cape 23 ...	8·5	6 12	49 5	01	63·0	4·42	1·0	...	1	...
Innes 281 ...	8·7	6 18	44 45	09	7·3	6·29	1·8	2, 7	2	...
Harvard ...	6·8	6 20	45 35	14	4·0	34·2	3·0	4, b	1	...

Star.	Mag.	R. A. 1900 h m	S. Dec. 1900 ° ′	1901·+	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A.	B.	No of Nights.	Remarks.
Innes 282 ...	7·7	6 22	50 29	49	314·4	1·44	2·2	y, b		2	...
G Puppis ...	6·0	6 23	48 7	49	133·3	1·18	...	y, b		2	21
Sellors 7 ...	5·3	6 27	50 10	02	...	...	...	...		1	22
10 Canis Maj.	5·1	6 41	30 58	13	97 ±	36·1 ±	5·4	...		1	23
Innes 179 ...	6·9	6 41	30 29	13	226·7	4·49	2·5	3, b		1	...
„ 184 ...	8·5	6 42	64 25	14	236·0	5·96	2·5	2, —		1	...
h 3891 ...	6·0	6 42	30 51	05	224·0	4·59	2·9	1, B		1	...
Innes 180 AB	8·5	6 42	52 19	01	342·8	0·78	0·5	0, 0		1	...
„ AC	...	...	...	01	243·1	42·7	4·5	...		1	...
Innes 351 ...	6·9	6 42	71 40	14	332·1	10·8	3·5	4, -		1	...
„ 157 ...	7·0	6 45	54 35	07	352·4	...	2·5	...		1	...
„ 158 ...	7·2	6 45	48 27	07	185·9	2·06	3·0	2, —		1	24
„ 181 ...	8·0	6 47	44 56	97	254·4	0·79	0·2	...		1	...
„ 182 ...	8·0	6 47	28 36	13	141·4	0·74	0·5	...		1	25
„ 159 ...	6·4	6 47	45 20	14	322·5	6·52	...	6, B		1	...
Cape 19 ...	9·0	6 49	47 38	14	121·4	2·48	0·0	0, 0		1	...
Innes 65 ...	6·3	6 54	35 23	55	200·0	[0·58]	0·1	3, 3		2	26
„ 66 ...	7·7	6 55	35 17	13	253·9	1·80	1·3	2, —		1	...
Harvard AB Lac. 2553 AC	6·7	6 55	30 52	13	$\begin{cases} 9^m \\ 10^m \end{cases}$	35 ± 70 ±	... ...	... ...		1	...
h 3932 ...	7·3	6 59	77 39	13	283·8	8·44	2·0	1, b		2	...
Innes 184 ...	8·0	7 8	60 25	55	182·4	0·81	...	0, 0		2	...
h 3941 ...	6·9	7 8	60 13	97	303·0	0·98	...	4, 4		1	...
Innes 7 ...	7·3	7 15	48 49	55	209·3	0·97	...	4, 4		2	...
C.P.D. 2034	8·7	7 16	21 42	99	275·7	4·95	0·7	...		1	27
h 3996 ...	7·6	7 28	84 17	14	254·8	16·2	3·5	...		1	...
d_2 Puppis ...	5·9	7 36	37 55	97	152·7	1·43	...	...		1	...
C.P.D. 1991	9·0	7 41	30 18	09	1·8	0·88	0·3	...		1	28
ζ Volantis ...	3·8	7 43	72 22	15	116·4	16·6	...	3, B		1	...
Innes 186 ...	7·4	7 45	30 18	54	198·7	1·02	0·2	...		2	...
„ 286 ...	8·6	7 50	47 43	54	292·2	2·54	0·1	0, 0		2	...
h 4023 ..	7·5	7 51	70 31	57	220·2	1·76	0·2	b, 5		2	...
Innes 26 ...	6·7	7 54	47 37	54	30·6	0·85	0·8	3·5, 3·5		2	29
.. 29 ...	8·0	7 55	60 20	98	186·7	3·22	1·3	...		2	30
.. 163 ...	8·2	7 57	40 18	99	135 ±	0·5 ±	...	...		1	...
.. 190 AB	7·7	8 2	54 42	56	118·6	2·45	2·8	1, —		2	...
. 190 AC	...	...	...	56	143·9	24·0	6·3	....		2	31
„ 165 ...	8·9	8 7	48 54	99	92·8	0·66	0·5	....		1	...
.. 167 ...	8·5	8 12	62 11	13	232·1	1·14	0·5	0, 0		1	...

Star.	Mag.	1900 R.A. h m	1900 S. Dec. ° ′	1901·+	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A.	Colours. B.	No. of Nights.	Remarks.
B Velorum ...	4·8	8 19	48 10	99	141·0	0·92	2·5	...		1	32
P viii. 60 ...	6·5	8 19	26 2	40	225 ±	12 ±	5·0	...		1	33
C. Z. 8h 2087	8·0	8 26	38 16	40	190 ±	0·6 ±	0·3	...		1	34
Innes 313 ...	7·2	8 27	41 11	15	216·7	3·75	...	3, B		1	35
,, 355 ...	8·2	8 32	20 43	99	39·2	0·75	0·3	4, 4		1	...
,, 357 ...	8·4	8 58	23 21	99	178·8	0·69	0·4	...		1	...
Cordoba (21)	8·3	9 6	43 46	61	47·6	2·78	0·9	...		2	41
C.P.D. 1034	8·4	9 16	69 58	30	340 ±	5 ±	0·4	...		1	36
Innes 12 ...	5·4	9 18	74 28	09	267·2	0·38	0·4	3, 3		1	...
ψ Argus ...	3·5	9 27	40 2	17	307·2	0·70	0·5	...		2–1	37
Innes 31 ...	9·2	9 28	56 33	62	156·9	3·16	0·3	...		2	...
,, 289 ...	8·2	9 29	73 13	17	257·5	0·79	0·4	...		2	38
,, 200 ...	7·7	9 29	60 48	17	358·0	1·20	2·2	y, b		2	39
,, 201 ...	8·2	9 31	73 18	17	152·1	2·07	2·2	2·5, b		2	...
λ 115	5·5	9 34	53 13	20	180 ±	0·7 ±	0·2	Y, Y		1	40
Innes 202 ...	7·0	9 35	39 10	97	176·2	1·58	2·0	3, b		1	...
,, 320 ...	8·6	9 36	66 15	08	49·0	1·04	1·2	0, 0		1	41
,, 321 ...	9·3	9 37	58 49	09	209·8	2·03	0·0	0, 0		1	...
C. Z. 9h 3089	8·5	9 41	37 6	97	340·3	0·72	0·1	...		1	42
Hargrave 28	7·8	9 42	59 1	09	285·1	1·98	2·5	4, b		1	43
Innes 172 AB	7·7	9 43	37 16	97	311·9	1·04	...	...		1	...
,, AC	...	...	...	97	200 ±	10 ±	15m	...		1	44
,, AD	...	...	...	97	270 ±	30 ±	13m	...		1	...
Innes 204 AB	7·2	9 44	69 39	08	124·3	1·53	2·5	...		1	...
,, AC	...	...	...	08	319·5	3·65	4·0	...		1	45
Cordoba [78]	9·0	9 45	44 26	09	109·4	1·89	0·2	0, 0		1	...
φ Argus ...	3·7	9 53	54 6	28	7·4	37·0	7·8	...		1	46
Innes 322 ...	9·0	9 55	62 5	28	68·0	2·00	0·5	...		1	47
,, 290 ...	9·2	9 59	59 36	09	272·0	2·68	1 2	...		1	...
,, 173 ...	5·2	10 2	46 53	08	61·2	0·3 ±	2·0	5, 5		1	48
,, 361 ...	8·5	10 9	46 59	28	135·1	4·36	1·8	2, b		1	49
,, 207 ...	8·5	10 14	32 43	28	323·3	{3·49 or 2·62}	0·2	1, 1		1	50
,, 208 ...	7·5	10 20	43 44	22	30·6	0·82	0·8	...		1	51
,, 33 AB	9·3	10 28	61 3	09	41·6	0·65	0·2	0, 0		1	52
,, ,, AB, C ...		...	...	09	116·7	5·07	0·1	0, 0		1	...
Innes 32 ...	9·0	10 28	61 17	09	345·1	5·28	2·0	...		1	...
C. Z. 10h 2838	8·7	10 40	36 21	20	350 ±	1 ±	0·6	...		1	53

Star.	Mag.	1900 R.A. h m	1900 S. Dec. ° ′	1901·+	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A. B.	No. of Nights.	Remarks.
C.P.D. 3761	8·8	10 42	56 48	50	240 ±	3 ±	0·3	...	1	54
Innes 212 ...	7·0	10 58	81 1	54	151·2	0·61	0·0	4, 4	1	55
„ 295 ...	8·6	11 4	61 0	54	192·2	1·59	2·5	2, —	2	...
„ 213 ...	8·0	11 6	32 1	53	127·1	1·01	2·5	...	1	...
„ 231 ...	7·3	11 8	70 40	54	2·2	2·57	3·2	2, b	2	...
„ 307 ...	8·5	11 35	51 8	53	35·8	0·86	0·2	3, 2	1	...
„ 34 AB	5·1	11 35	64 51	53	234·1	38·1	6·9	4, —	1	...
„ „ AC	...	...	...	53	31·7	42·4	7·4	...	1	55
„ 308 ...	8·5	11 36	49 39	53	128·1	1·33	0·0	Y, b	1	56
„ 215 ...	6·9	11 57	34 6	53	236·7	1·13	0·8	...	1	...
„ 81 ...	9·0	12 10	29 13	54	334·0	2·60	1·5	2, b	1	...
α Crucis ...	1·0	12 21	62 33	67	118·2	4·63	...	...	2	57
Innes 35 ...	8·5	12 21	76 7	54	316·3	2·25	0·3	...	1	58
„ 36 ...	7·7	12 23	61 19	53	324·4	21·7	3·3	...	1	...
γ Centauri ...	2·4	12 36	48 25	73	355·1	1·40	...	...	1	57
β Muscæ ...	3·3	12 40	67 34	67	343·0	1·21	0·3	...	2	57
Ref. Cat. 14 AC	4·7	13 6	59 23	58	257·6	49·8	7·3	...	1	59
Lac. 5431 ...	7·5	13 8	62 7	58	140·1	8·28	3·5	4·5, b	1	60
Cape 32 ...	8·4	13 20	52 46	58	263·1	4·26	0·6	—, r	1	...
C. Z. 13^h 1224	8·8	13 22	42 42	43	153·1	...	1·7	4, b	2	61
λ 180	7·0	13 25	41 57	43	230·6	3·68	2·5	4, B	2	62
C. Z. 13^h 2913	8·5	13 49	42 5	30	50 ±	0·3 ±	0·3	Y, Y	1	63
h 4636 ...	8·9	13 52	39 29	60	33·5	cloud	0·7	...	1	...
Harvard ...	6·4	13 53	65 47	58	196·7	46·0	5·6	...	1	4
Innes 225 ...	7·2	13 54	62 28	58	299·9	2·14	3·5	5, b	1	41
Russell 231...	9·0	13 54	66 42	58	163·0	3·86	0·7	3, b	1	41
Sellors 19 ...	6·9	14 1	49 24	58	244·0	0·89	0·2	3, 3	1	65
h 4649 ...	8·3	14 2	59 15	58	246·3	8·36	0·2	6, 5	1	...
h 4667 ...	7·3	14 13	73 6	60	142·5	2·26	0·3	2, b	2	...
Dunlop 159 AB	5·0	14 15	58 0	61	161·7	9·48	...	5, —	1	...
„ AC	...	...	...	61	250 ±	19 ±	...	...	1	66
„ AD	...	...	...	61	4·1	45·4	...	...	1	...
τ_1 Lupi ...	4·4	14 20	44 56	30	185 ±	0·3 ±	0·1	...	1	67
„ ...	...	...	...	58	177·1	...	...	4, 4	1	...
Innes 326 ...	7·2	14 21	75 50	48	121·8	2·30	3·0	5, b	3	...
Bris. 4918 ...	6·3	14 23	67 16	58	193·8	35·2	7·7	...	1	68
Harvard ...	6·5	14 27	52 14	58	180 ±	15 ±	8·5	4, —	1	69
α Lupi ...	2·5	14 35	46 58	58	232·1	27·5	11·5	...	1	70

Star.	Mag.	1900 R.A. h m	1900 S. Dec. ° ′	1901·+	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A.	B.	No. of Nights.	Remarks.
Cordoba ...	8·3	14 37	75 34	58	120·9	11·9	1·5	...		1	71
Innes 368 ...	9·2	14 38	62 25	58	4·0	3·20	1·2	2, b		1	...
h 4695 ...	6·9	14 41	74 31	58	290·2	17·4	4·1	...		1	...
Innes 84 ...	7·5	14 49	36 1	40	260·1	4·07	3·0	—, 7		2	72
„ 237 ...	8·8	14 53	41 33	40	192·6	0·90	0·5	5, 5		2	...
„ 85 ...	8·5	14 59	35 32	27	182·0	1·05	0·5	0, 0		1	...
λ Lupi ...	4·3	15 2	44 54	27	189·7	0·83	0·3	2, 2		1	...
Innes 238 ...	8·2	15 5	44 38	27	141·2	3·30	2·5	2, —		1	55
Harvard ...	7·0	15 9	43 47	41	38·6	13·3	2·5	2, 7		2	...
Innes 86 ...	9·5	15 15	37 54	27	262 2	2·10	1·0	...		1	...
γ Lupi ...	3·0	15 28	40 50	35	95·0	0·74	...	...		2–1	73
C. Z. 15^{h} 2416	9·3	15 36	44 24	66	197·4	1·20	0·6	4, 4		1	74
Innes 334 ...	9·0	15 54	71 37	53	139·8	2·11	2·0	—, 6		1	...
Cordoba [44]	8·3	16 5	56 9	56	131·6	3·17	2·0	1·5, b		2	...
C.P.D. 10015	9·1	16 27	52 27	60	120 ±	2 ±	0·5	...		1	75
C. Z. 16^{h} 2120	8·9	16 32	46 27	70	320 ±	2 ±	0·2	...		1	76
Innes 100 ...	6·8	16 48	73 16	53	180·1	haze	1·5	3, 3		1	77
h 4904 ...	7·4	16 57	75 15	59	187 0	7·04	2·0	2, b		1	41
C. Z. 16^{h} 4210	8·7	17 1	41 49	70	90 ±	2·5 ±	0·1	...		1	78
Lac. 7131 ...	7·1	17 1	41 29	70	180 ±	0·8 ±	0·5	5, 5		1	78
Mœsta 1541	8·7	17 5	41 52	70	30 ±	5 ±	2·5	...		1	79
Lac. 7177 ...	7·1	17 9	42 14	70	160 ±	1·5 ±	2·0	...		1	80
Brisbane AB	5·5	17 11	46 32	67	77·3	2·17	...	...		3	...
C. Z. 17^{h} 706	8·8	17 12	39 40	70	40 ±	4 ±	2·0	...		1	81
Lac. 7211 ...	7·5	17 12	44 7	64	11·7	0·51	0·1	...		1	82
C. Z. 17^{h} 802	8·3	17 14	42 33	70	280 ±	2·5 ±	1·8	...		1	83
Innes 376 ...	9·0	17 24	65 57	64	37·6	2·17	1·0	...		1	...
h 5014 ...	5·2	18 0	43 25	77	242·3	1·58	0·1	...		1	...
Harvard ...	6·0	18 0	73 41	64	232·1	2·57	3 0	2, 4		2	84
Lac. 7585 ...	6·9	18 5	50 35	66	160 8	2·27	4·0	...		1	85
k 5029 ...	7·2	18 6	57 53	72	109·9	2·39	0·2	2, b		2	86
h 5031 ...	8·0	18 7	47 24	61	82·8	25·7	1·7	...		2	87
Lac. 7574 ...	6·5	18 7	68 16	66	298·3	2·51	3·5	...		1	85
C.P.D. 5842	7·9	18 14	62 38	64	55·4	5·66	0·2	...		3	88
Cordoba [51]	7·9	18 16	42 49	77	138·9	3·60	0·3	...		1	89
C.P.D. 8421	9·3	18 26	42 44	77	45·9	6·54	0·4	...		1	90
κ Cor. Aust.	5·7	18 26	38 48	71	358·7	21·8	0·7	—, 2		2	...
Lac. 7881 ...	7·0	18 45	41 49	60	340·0	34·9	3·5	5, —		2	85

Star.	Mag.	1900 R.A. h m	1900 S. Dec. ° ′	1901 +	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A.	Colours. B.	No. of Nights.	Remarks
h 5069 ...AB	7·5	18 47	61 57	74	82·9	0·85	0·1	...		2	..
AC	...	...	...	82	93·0	15·3	...	...		1	...
Gilliss 248 ...	8·0	18 48	66 2	66	129·6	4·19	0·2	2, b		2	...
ζ Sagittarii	2·7	18 56	30 1	73	61·9	0·65	0·2	...		4–3	...
Gale	5·6	19 7	66 50	82	39·5	0·82	0·2	...		1	...
λ 382	8·0	19 28	41 38	81	307·3	1·99	0·4	...		2	...
Innes 120 ...	7·0	19 40	62 3	64	152·0	0·72	0·0	2, 2		2	...
h 5148 ...	7·1	19 43	45 38	83	318·0	13·9	4·5	...		2	...
Lac. 8293 ...	6·0	19 53	37 58	83	209·4	22·9	7·5	...		2	91
„ 8300 ...	7·2	19 55	38 51	84	147·1	0·55	0·4	2, 2		2	91
λ 404	6·6	19 59	33 17	85	74·2	0·81	2·0	...		2	92
Lac. 8337 ...	6·5	20 3	57 49	64	227·9	0·67	0·3	2, 2		2	91
„ 8343 ...	6·9	20 6	64 44	68	306·0	17·4	3·1	2, —		2	91
C. Z. 18h 184	8·5	20 7	62 28	84	281·9	0·83	2·3	...		3	93
Cordoba [57]	7·8	20 14	55 7	84	1·5	4·35	2·0	2, b		2	...
h 5182 ...	6·3	20 17	81 18	84	356·9	26·8	...	3, b		1	..
Innes 41 ...	7·0	20 30	45 54	69	0·8	1·77	1·0	2, b		2	...
„ 17 ...	7·2	20 38	50 51	85	219·5	0·90	0·1	...		1	..
„ 300 ...	8·5	20 41	17 4	85	299·1	3·91	0·1	b, 3		1	...
„ 257 ...	7·8	20 57	76 23	80	293·3	1·51	0·4	...		2	...
Lac. 8625 AB	5·9	20 59	73 34	76	180?	...	...	...		1	94
				85	280?	...	...	...		1	...
AB, C ...	...	...	...	85	137·4	8·14	...	...		1	...
Brisbane ...	5·7	21 42	47 45	84	359·4	46·6	...	2, 6		2	...
r 5292 ...	9·0	21 47	85 13	85	155·7	5·47	...	...		1	...
Lac. 8939 ...	6·3	21 48	62 21	82	113·1	0·3 ±	...	2, 2		2	95
Cordoba [61]	8·6	21 54	30 28	84	258·7	3·09	...	y, b		2	...
λ 466	8·5	21 59	40 11	81	267·7	2·31	0·6	...		2	...
h 5316 ...	8·0	22 0	56 37	82	141·9	3·83	2·0	2, b		2	...
C.P.D. 6626	8·4	22 6	61 42	85	194·5	5·28	0·2	...		3	96
Lac. 9062 ...	7·3	22 11	68 48	85	89·3	26·7	4·2	...		1	91
π_2 Gruis ...	5·8	22 17	46 26	85	206·7	4·48	...	...		1	...
Innes 383 ...	5·4	22 18	58 18	85	251·1	19·7	9·6	...		1	97
„ 137 ...	6·9	22 21	58 31	85	335·2	...	...	...		1	...
Lac. 9147 ...	6·8	22 25	49 56	76	283·6	19·7	5·2	...		1	98
Cordoba [63]	6·5	22 37	47 43	76	131·6	8·00	...	3, r		1	...
η Gruis ...	4·9	22 40	54 2	76	184·9	23·9	7·6	...		1	...
Sellors ...	8·8	22 59	75 18	79	73·4	3·61	2·5	...		2	...

Star.	Mag.	R.A. 1900 h m	S. Dec. 1900 °	1901·+	Pos. Angle. °	Dist. ″	Diff. Mags.	Colours. A.	B.	No. of Nights.	Remarks.
Sellors AC ...	...	...	...	79	3·35 ±	25 ±	3·4	....		2	99
Lac. 9444 ...	6·7	23 14	34 15	82	307·0	43·6	5·3	...		1	100
Dunlop 248	6·0	23 15	50 51	82	210·3	16·8	...	...		1	101
Innes 25 ...	7·5	23 30	58 3	79	54·3	0·76	0·1	2, 2		2	...
Lac. 9545 ...	7·0	23 35	47 53	87	66·4	2·05	3·0	2, B		2	91
Innes 146 ...	7·3	23 50	37 55	76	222·6	0·68	1 4	...		1	..

Remarks.

No.

1. Common proper motion of 0″·485. Six small stars near.
2. A 14th mag. 360° ± 20″ ±.
3. Is C.P.D. −57° No. 7. *h* has 173°·6.
4. South star *decidedly* fainter and yellower. This difference of magnitude is in accordance with all the other observations, excepting those of the Southern Meridian Photometry, which makes the southern star 0·17 mag. brighter.
5. Angle has decreased about 27° in five years.
6. This fine pair was discovered at Arequipa and communicated by Professor Pickering. Bailey gives 1896·0. Possibly elongated 90°. Motion?
7. The proper motion of the chief star is 0″·181 towards 70°·6.
8. Fairly accordant angles, but elongation not sure.
9. This is a highly coloured pair. Once the comp. was called "red-brown" and once "purplish."
10. This is not the *h* companion, which has only been seen by *h*, and, he remarks, "must be verified." The companion measured was noted by Mr. Clymer at Arequipa in 1899, and communicated by Professor Pickering.
11. The p. m., if any, is very small.
12. Found with the 18-inch telescope = Innes 386. This is the following of two nearly equal mag. stars, the pr. being 7·0 mag., colour yellow 3. The close pair is white. As a wide pair this is certainly *h* 3525, with an error of 1° in *h*'s declination. *h* 3525 was not found at the Sydney Observatory in 1879. *h* 1836·8, 274°·3, 35″·1, 0·0, 1n.
13. Found with the 18-inch telescope = Innes 387.
14. Wrongly identified by the λ observers. It is O.A. 2112.
15. Found with the 18-inch telescope = Innes 388.
16. ,, ,, ,, 389.
17. The faint companion was added with the 18-inch, with which it is very difficult. The *h* pair is in certain motion, 24° in 67 years—probably due to pr. motion in one of the components.
18. The chief star has been measured as λ 40, dist. = 0″·43—now certainly single.
19. Found with the 18-inch telescope = Innes 390.
20. Two 12th mag. stars, 3″ apart, are 1′ N.
21. P.m. = 0″·03 towards 270°.
22. In the reference catalogue of southern double stars the measures of this star as a triple are given. Bailey (*Harvard Annals*, xxxii. pp. 300, 308) remarks that it is a quadruple. It was observed here on one night, C−D 105°·1, 0″·3 ±, d.m. 0·1, elongation perhaps doubtful, star bluish. At the same time it was noted that in A−B the smaller star (0·1 mag.) is *following*, both stars yellow.
23. From the Harvard list. Angle and distance only roughly taken; still the latter is certainly nearly correct. Bailey has 15″ ±.

No.

24. The proper motion is insensible.
25. Three faint stars about 60″ N. ±.
26. The distances are certainly too great, stars only slightly elongated. This pair was found with the 7-inch in 1896. The measures and estimates are:

1896·9	150° ±	0″·6 ±	Innes.
1897·3	160 ±	...	„
1898·3	190·3	0·26	See.
1900·5	188·7	0·25 ±	Innes.
1901·5	200·0	0·4 ?	„

The increase in angle is about 10° per annum.

27. The chief star of a little cluster. C.P.D. mag. = 8·4, B.D. = 9·0. New? = Innes 391.
28. Found with the 18-inch telescope = Innes 392.
29. Evidently fixed. Several very faint stars near.
30. There is a 12th mag. pair 2′ N. pr.
31. New.
32. Proper motion = 0″·02 towards 270°. The measures agree with the estimates made four years ago.
33. Found with the 7-inch telescope = Innes 393. The p.m. is insensible. Near Hough 526.
34. Found with the 7-inch telescope = Innes 394. This star is the N.f., and brightest of a group of three stars.
35. A 13th mag. star is 30″ ± pr.
36. New = Cape 33. Found by Mr. R. T. Pett at the transit circle.
37. Present increase of angle = 15° per ann. The period will be about 24 years. Is difficult to measure, distance diminishing.
38. A 14th mag. star, 38″, 6°.
39. A 13th mag. star, 30″ N. pr.
40. Estimated with the 7-inch.
41. Several faint stars near.
42. Found with the 18-inch = Innes 395.
43. The only measure found of this pair. A very minute double star, 20″ pr., a little S.
44. C and D were added with the 18-inch.
45. C added with the 18-inch. The p.m. of A is very small.
46. The faint companion was picked up at the 7-inch = Innes 396.
47. Some very faint stars within 20″.
48. The p.m. is 0″·11 towards 116°. Binary system.
49. This is C. Z. 10^h 591, and is the N. pr. of two stars. Original identification erroneous.
50. MS. of number of revolutions of micrometer equivocal; one of the two distances will be correct.
51. A 12th mag. star 30° ± 15″ ±.
52. The close pair is new; added with the 18-inch.
53. Found with the 7-in. = Innes 397. Lac. 4437, mag. 6·8, is 3½′ S.
54. „ „ „ 398.
55. The p.m. is very small.
56. Pr. star yellow, following star bluish. There are two faint comites:

13^m 45° ± 10″ ±
12^m 30° ± 25″ ±.

57. Taken in sunshine.
58. Colours slightly contrasted.
59. Chief star = λ 170 not seen double, but definition not very good. The distant star alone seen also at Harvard. Many faint stars about; one, 15^m N., is closer than the star measured.

No.

60. Found with the 7-inch = Innes 399. There is an 11^m star 60″ due S.
61. Found with the 7-inch = Innes 400. The distances, viz. 4″·60 and 5″·56, are discordant; a 3rd observation must be taken to see which is correct. There is a 14th mag. star 15″ pr. C.Z. 13^h 1221, mag. 9·1 is closely N. pr.
62. A 15th mag. star is at 12″ ± 83° ±, and there are two brighter stars 20″–30″ distant, one N., one S.
63. Found with the 18-inch = Innes 401. C.Z. 13^h 2915 mag. 9·1 is closely N.f., and with C.Z. 13^h 2913 forms *h* 4625.
64. Many faint stars about, a 15th mag. 46″ ± 317° ±.
65. Considerable change shown. Common p.m. of 0″·134 towards 338″·7.
66. New, 15th mag. too faint to measure.
67. New, found with the 18-inch = Innes 402. The p.m. is under 0″·01.
68. This very difficult companion was measured whilst making an attempt (unsuccessful) to see the three comites to the chief star found at Arequipa by Professor W. H. Pickering. The p.m. of the chief star is 0″·06 towards 180°.
69. Too faint to measure.
70. The p.m. of the chief star is 0″·044 to 229°·1.
71. A 13th mag. star completes a neat triangle. The distance derived from the Cordoba meridian observations seems to be too small.
72. An 11th mag. star 20″ ± N.f.
73. The distance is probably too great. There is no certain change in this pair since 1897.
74. Found at the 7-inch = Innes 403. Mag. taken from Cordoba D.M. C.Z. has $8{\cdot}0^m$, which is more likely.
75. Found with the 7-inch = Innes 404.
76. ,, ,, ,, 405. There is an unrecorded $9^m{\cdot}5$ star 2′ N., not in any D.M.
77. The p.m. is under 0″·04.
78. Both found with the 7-inch = Innes 406 and 407.
79. Found on a *Carte du Ciel* plate by Mr. R. Woodgate, = Cape 34.
80. Found with the 7-inch = Innes 408.
81. ,, ,, = ,, 409. The N. star of a triangle.
82. Found at Arequipa and communicated by Professor Pickering. Mr. Clymer gives 1899, 350° ± 0″·6 ±. A fine pair.
83. Found with the 7-inch = Innes 410. C.Z. 17^h No. 808, mag. 8·6, is 5 secs. following.
84. This fine pair has a common proper motion of ″·231 towards 195″·3.
85. Found by Professor Bailey and communicated by Professor Pickering.
86. Faint star near.
87. On the occasion of the 2nd measure the chief star was suspected to have a close companion S. pr.
88. Found by Mr. R. T. Pett at the Transit Circle = Cape 35. Colours slightly contrasted. In a triangle of faint stars, with many very faint stars interspersed.
89. Two faint stars N. and S.
90. Found on a photo-plate by Mr. Woodgate = Cape 36. There is a 12^m star 90° ±, 15″ ± (18-inch).
91. Found at Arequipa by Mr. Clymer and communicated by Professor E. C. Pickering.
92. A 12^m, 83° ± also seen.
93. Found with the 18-inch = Innes 411.
94. Elongations very doubtful; this pair must be in very rapid motion.
95. Communicated by Professor Pickering. Mr. Clymer at Arequipa gives 1899, 105° ± 0″·5 ±. My settings were quite independent, but at no time was the elongation over-certain.

Proper motion in α: no material.
,, ,, $\delta = -0''{\cdot}08$.

No.
96. Found by Mr. R. T. Pett at the transit circle = Cape 37.
97. These measures were very hard to get—little better than estimates.
98. Found at Arequipa by Mr. Clymer. The p.m. of the chief star is 0″·22 towards 222°·2.
99. Added with the 18-inch.
100. Single distances, clouds, difficult. Found at Arequipa by Mr. Clymer.
101. Common proper motion of 0″·044 towards 154°·7.
102. This triple system—although showing no great change—has a common proper motion of 0″·08 towards 112°·0.

α Centauri.

These measures were taken with the Repsold micrometer on the 18-inch refractor.

Date.	Pos. Ang.	Distance.	Observer.	Number.	Telescope.
1901·07	210°·5	21″·74	Gill	5–4 days	E.
·07	210°·7	·74	Innes	11 „	W.
·26	210°·6	·76	„	4 nights	W. and E.
·59	210°·7	·76	„	6 „	„
·87	210°·7	·67	„	6 days	„

Each measure consists of four settings for position angle and of four double distances for distance.

The means for the previous year (reduced to the same value of the micrometer screw = 17″·603) are :

1900·34	210°·2	21″·72	Innes	18–19 days, &c.
·35	210°·5	21·67	Lunt	17 „

The progressive and periodic errors of the screw have been determined ; the former are given in *Monthly Notices R.A.S.*, vol. lxi. p. 613; the periodic errors are also very small, and are given with accuracy by the expression

$$\begin{aligned} &{}_{R} \qquad\qquad {}_{R} \\ &-0''\cdot00028 \cos u \; -0''\cdot00022 \sin u \\ &-0''\cdot00008 \cos 2u \; +0''\cdot00004 \sin 2u \end{aligned}$$

The measured distances of *α Centauri* have been increased by 0″·01 ; half of this is due to the screw errors, the remainder to refraction.

The following stars from various double star lists were observed as single—generally on one night only—so that it is only in a few cases that a definite conclusion has been reached. It was considered on the nights of observation that the definition was sufficiently good to show the duplicity if the star was really double in the sense of previous observations, but, as every observer knows, some nights are not as good as they seem to be. The

greater number of the stars will be further examined. This list completes the record of observation.

Star.	Mag.	R.A. 1900. h m	S. Dec. ° ′	Date of Observ. 1901·+.	Remarks.
κ Phenicis ...	3·9	0 21	44 14	82	Not seen double. See has 13th mag. 8″ in.
α „	2·4	0 21	42 51	82 and 94	Is λ 6, 13th mag. 9″·7 6n. Not seen double. On the second occasion the bright star was kept outside the field.
λ 30 ...	6·7	3 42	54 35	01	Certainly single. This is the chief star of *h* 3592, which has a com. p.m. of 0″·065 towards 23°·5.
α Columbæ ...	2·7	5 36	34 8	02	Not seen, good.
Innes 162 ...	7·5	7 53	52 38	99	Single.
„ 169 ...	7·2	9 7	42 52	09	Single.
„ 203 ...	8·2	9 36	62 6	09	Single. (Found 1897 May 21, and confirmed 1897 May 28.)
Lac. 4096 ...	8·0	9 51	70 59		This was found to be double at the 7-inch 1901·4, 260° ± „ 1″ ± companion = 11ᵐ, but on 1901·97 the small star could not be seen with the 18-inch.
Innes 176 ...	9·6	11 1	46 53	53	No companion seen.
λ 145 ...	6·4	12 5	37 19	54	Round, under ¼″ if double.
Innes 309 ...	7·7	12 26	77 38	54	Not seen. (Seen *twice* in 1898.)
„ 219 ...	8·5	12 26	55 34	54	Not seen.
Harvard ...	6·2	14 38	55 11	58	The nearest *comes* seen to this star is due f. = 90°, and is much nearer Bris. 5026 than Lac. 6057. Bris. 5026, colour 6.
Innes 226 ...	7·0	14 48	33 44	27	Not seen; hazy.
Lac. 6847 ...	6·8	16 29	72 6	59	Not seen, but definition not good. This is a very difficult pair found by Professor Bailey and communicated by Professor E. C. Pickering.
λ 321 ...	7·0	17 8	39 39	74	Single.
λ 330 ...	8·7	17 24	30 11	70	Single; a faint comes is 30″ pr. Professor See's measure may be transferred to the double star 1ᵐ 23° f. and 2′·2 S. = OA 16867.
Lac. 7561 ...	6·9	18 5	63 43	66	No companion seen. Professor Bailey has 13ᵐ·2, 19″ ±. Chief star, colour orange = 5.
δ_1 Telescopii	5·1	18 24	45 59	66	Not seen double, fair definition. Professor Bailey has 1894·7, elongated.
λ 359 ...	7·7	18 40	43 53	81	Probably single.

Star.	Mag.	R.A. 1900. h m	S. Dec. 1900. ° ′	Date of Observ. 1901+.	Remarks.
λ 359 ...				82	Single; good definition. Neighbouring stars also single.
λ 373 ...	9·0	19 19	42 5	80	Single; several neighbouring stars also examined.
λ 387 ...	6·7	19 33	42 30	80	Single.
λ 403 ...	7·2	19 57	36 20	84	Neither *comes* seen.
Innes 124 ...	7·7	20 9	63 28	84	Certainly single. This star has been struck out of the list of double stars.
„ 127 ...	9·0	20 27	44 51	85	Single. Seen *twice* in 1896 and measured once in 1900.
„ 131 ...	9·0	21 15	52 12	76	Not found; good search. This star has now been struck out of the list.
λ 494 ...	8·9	23 36	34 45	82	Not seen double.
λ 499 ...	8·1	23 55	40 45	79	Not seen double (two nights).

Errata, &c., in the Reference Catalogue of Double Stars.

Ref. Cat. h	No.	
0	14	*h* 3362. This star and several others observed by *h* in the same sweep require a correction of $+1^h$ in R.A. *h* 3362 is thus the same star as *h* 2043 = Ref. Cat. 1^h No. 24.
4	53	This is also P. iv. 230. Although a wide pair (14″) there is a common proper motion of 0″·11 towards 328°·0.
7	97	The chief star is V Puppis.
8	22	This is C. Z. 8^h 758, mag. 8·6. $\alpha = 8^h\ 10^m\ 15^s$ $\delta = -37°\ 22'·5$.
	45	This is C. Z. 8^h 2233, mag. 7·8. $\alpha = 8^h\ 27^m\ 37^s$ $\delta = -36°\ 21'·2$.
9	38	This is Lac. 3833, mag. 6·0. $\alpha = 9^h\ 22^m\ 23^s$, $\delta = -28°\ 21'·2$.
13	53	This wide pair has a common p.m. of 0″·154 towards 270°·0.
17	70	Identity correct as printed.
18	92	This is ν_1 Sagittarii, as pointed out by Professor See. The p.m. is 0″·043 towards 243°·8
19	18	Identity correct as printed.
20	52	This 18″ pair has a common p.m. of 0″·24 towards 131°·0.
21	39	*For* 8826 *read* 8626.

To these may be added the corrections published by other observers; *e.g.* see Mr. Cogshall's lists, *Ast. Jour.* Nos. 505–6.

Errata in Cape Double Star Results, 1900 (*Monthly Notices*, vol. lxi. No. 9).

Page 581, middle, *for* 10° ± *read* 150° ±.
„ 582, lines 6–7, lower *h* 3646 one line.
„ 585, line 3, *for* ″·11 *read* 9″·11.
„ 588, „ 20, *for* ... (1st col.) *read* 80.
„ 592, No. 29, *for* ω (omega) *read* o (omicron).
„ 593, line 17, No. 67, insert semicolon after "referred to."
„ 595, „ 2, „ 32, *for* Obs. L. *read* Obs. L. and I.
„ 599, „ 4, *for* 5859 *read* 5898.
„ 600, No. 93 AC 1900·37, *add* mag. 10·5 new.
„ 609, line 7, *for* "Found" *read* "Observed."

Royal Observatory, Cape of Good Hope:
1902 *January* 14.

Results of Double Star Measures with the 8-inch Equatorial at Windsor, New South Wales, in 1901.

By John Tebbutt.

Ref. No.	Star.	Observed Mags.	Approx. Place of Star 1901·0. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position Angle. °	Distance. ″	No. of Obs.	Mag. Power.	Eyes.	Hour-Angles. h m	h m	Weight 1 to 5.
1	β Phœnicis	5, 5	1 1·7	47 15	·975	18·8	1·41	10–6	300	P	3 6 W	3 29 W	3
2	„	5, 5	„	„	·980	18·1	1·51	10–7	300	P	2 49 W	3 13 W	
3	κ Toucani	5, 8	1 12·4	69 24	·980	350·9	5·66	10–10	300	P	3 20 W	3 51 W	
4	„	5, 8	„	„	·983	354·0	...	10	300	R			
5	„	....	„	„	·983	354·2	...	10	140	R	1 34 W	2 32 W	2
	„	...	„	„	·983	352·0	...	10	300	P			
7	Lac. 1889	6, 6¼	5 28·1	42 22	·309	168·7	7·66	10–6	300	P	3 25 W	3 49 W	3
8	*h* 3784	6, 8½	5 35·4	46 9	·282	59·3	5·66	10–4	140	P	3 38 W	...	3
9	*h* 3789	8, 8¼	5 36·6	50 11	·309	359·5	9·25	10–6	140	P	3 55 W	4 17 W	3
10	*h* 3823	8½, 8½	5 56·7	31 3	·263	113·8	2·85	10–6	300	R	3 44 W	4 23 W	3
11	„	8½, 8½	„	„	·266	110·6	2·92	10–6	140	R	1 48 W	2 20 W	3
12	*h* 3834	6, 9	6 1·8	45 5	·263	227·9	3·77	10–7	300	P R	2 53 W	3 23 W	4
13	„	5, 9	„	„	·277	230·1	3·73	10–5	300 / 140	P	3 43 W	4 12 W	3
14	Lac. 2145	6, 6½	6 2·2	48 27	·260	37·7	1·89	10–7	300	P	4 24 W	4 51 W	4
15	„	...	„	„	·263	42·4	1·77	10–7	300	R	2 8 W	2 43 W	5
16	„	...	„	„	·266	42·0	...	9	300	R	2 27 W	...	3

Ref. No.	Star.	Observed Mags.	Approx. Place of Star 1901·0 R.A. h m	Dec. S. ° ′	Fraction of Year.	Position Angle. °	Distance. ″	No. of Obs.	Mag. power.	Eyes.	Hour-Angles. h m	h m	Weight 1 to 5.
17	Lac. 2145	...	6 2·2	48 27	·277	39·1	2·04	10–7	300	P	2 59 W	3 29 W	4
18	Lac. 2224	8, 9	6 11·6	61 27	·279	185·3	1·41	10–5	300	P	3 0 W	3 27 W	3–4
19	Lac. [2275]	7, 8	6 11·9	65 30	·279	116·9	21·13	10–7	140	P	2 22 W	2 51 W	3
20	Lac. 2402	5, 8	6 36·0	48 8	·279	320·3	13·63	10–6	300	R	3 18 W	3 46 W	3
21	*h* 3891	$5\frac{1}{2}$, 8	6 41·7	30 51	·309	224·7	4·87	10–7	$\left\{\begin{matrix}535\\140\end{matrix}\right\}$	P	3 53 W	4 18 W	3–2
22	γ Piscis Vol.	5, 8	7 9·6	70 20	·288	299·1	13·54	10–6	140	P	2 29 W	2 51 W	3
23	Lac. 2779	$6\frac{1}{2}$, 7	7 18·0	52 8	·288	21·5	9·99	10–7	140	P	2 57 W	3 17 W	3
24	*h* 3960	6, 7	7 18·6	48 20	·288	156·3	22·86	10–5	140	P	3 31 W	3 54 W	4
25	*h* 4414	5, 9	11 8·3	59 47	·249	217·7	(1·5)	10	300	P	3 1 E	2 34 E	3
26	,,	4, 11	,,	,,	·252	217·3	...	3	300	P	1 2 E	0 41 E	4
27	,,	5, 9	,,	,,	·260	221·5	...	10	300	P	2 23 E	2 0 E	4
28	*h* 4423	$6\frac{1}{2}$, $6\frac{3}{4}$	11 11·9	45 21	·236	276·7	1·62	9–6	300	R	2 20 E	1 52 E	3
29	,,	...	,,	,,	·238	276·9	2·34	10–7	300	R	2 33 E	2 7 E	4
30	*h* 4432	5, 6	11 19·1	64 25	·238	299·2	1·87	10–5	300	R	1 59 E	1 35 E	3
31	,,	$5\frac{1}{2}$, 7	,,	,,	·241	297·8	2·52	10–7	300	R	3 16 E	2 50 E	4
32	Brisb. 3574	8, $8\frac{1}{2}$	11 20·4	61 6	·249	25·7	2·07	10–6	300	P	2 23 E	1 46 E	4
33	,,	7, $8\frac{1}{2}$	,,	,,	·252	26·9	1·69	10–6	300	P	1 45 E	1 23 E	4
34	Dunlop 109	5, 8	11 23·8	42 8	·249	167·1	13·32	8–3	300	P	1 28 E	1 5 E	3
35	,,	5, 7	,,	,,	·252	167·0	13·20	10–6	300	P	2 53 E	2 26 E	3

Ref. No.	Star.	Observed Mags.	Approx. Place of Star 1901·0. R.A. h m	Dec. S. ° ′	Fraction of Year.	Position Angle. °	Distance. ″	No. of Obs.	Mag. power.	Eyes.	Hour-Angles. h m	h m	Weight 1 to 5.
36	N. Hydræ	$4\frac{1}{2}$, $4\frac{1}{2}$	11 27·4	28 43	·255	211·3	9·35	10–7	300	R	2 22 E	1 58 E	4
37	,,	5, 5	,,	,,	·257	212·2	9·05	10–6	300	R	2 26 E	1 58 E	3
38	*h* 4455	5, $7\frac{1}{2}$	11 31·7	33 1	·255	244·8	3·82	10–5	300	R	1 50 E	1 26 E	3
39	,,	5, 7	,,	,,	·257	245·4	3·75	10–6	300	R	3 42 E	3 17 E	4
40	β Hydræ	5, $5\frac{1}{2}$	11 47·9	33 21	·255	353·0	1·77	10–7	300	P	3 17 E	2 55 E	4
41	,,	5, $5\frac{1}{4}$	,,	,,	·257	350·5	1·60	10–7	300	P	3 23 E	2 53 E	4
42	,,	...	,,	,,	·260	351·0	1·73	10–7	300	P	3 41 E	3 17 E	4
43	ϵ Chamæl.	5, 7	11 54·7	77 40	·255	187·0	1·59	10–7	300	P	4 11 E	3 39 E	2
44	,,	6, $6\frac{1}{2}$	,,	,,	·260	186·8	1·57	10–7	300	P	2 26 E	1 59 E	5
45	β Muscæ	...	12 40·2	67 34	·222	343·1	1·57	10–6	300	R	2 11 E	1 37 E	3
46	,,	...	,,	,,	·225	342·9	...	10	300	P	3 43 E	...	4
47	,,	...	,,	,,	·236	347·1	...	10	300	P	4 44 E	4 3 E	2
48	,,	...	,,	,,	·236	344·4	...	10	300	P			3
49	,,	5, 5	12 40·2	67 34	·241	341·7	1·42	10–6	535	P	3 57 E	3 28 E	4
50	*h* 4634	...	13 50·7	55 33	·222	26·6	14·55	10–6	140	P	4 8 E	3 38 E	3
51	,,	...	,,	,,	·241	26·2	...	6	300	P	4 18 E	3 40 E	4
52	,,	...	,,	,,	·241	27·0	14·31	10–6	140	P			
53	α Centauri	...	14 32·9	60 25	·975	210·3	21·60	10–10	140	R	1 7 W	1 40 W	2
54	θ Gruis	5, 8	23 1·3	44 3	·975	27·3	1·46	10–5	300	P	4 11 W	4 35 W	3
55	,,	5, 8	,,	,,	·980	30·0	1·62	10–5	300	P	4 13 W	4 37 W	3

Remarks.

1, 2, 10, 37, 46, 49, the components were noted as equal. 13, principal component orange, companion blue. 18, the north component was noted as the brighter, but according to Innes' Reference Catalogue, Sellors made the south component the brighter. 20, 31, 38, principal components yellow, companions blue. Innes' Catalogue gives both components of 31 as yellow, and it would appear from the same authority that various colours have been assigned to the companion of 38. 22, both components orange. In 1888 and February of the current year the companion was noted by me to be blue. 25, observations very difficult: the distance is estimated. 26, I had doubts as to the actual existence of the companion, and thought it might possibly be a thickening of the diffraction ring at the spot. The companion 10 mag. measured by Pollock in 1889 not seen. 27, Herschel and Pollock's companion not seen. 36, the north following component was the brighter. 39, principal component orange, companion blue. 40, 41, 42, the south component slightly the brighter. 50, companion blue. 51, 52, principal star white, companion blue. 54, 55, companion pale blue.

The last four columns of the table have been repeatedly explained in previous publications of my double-star results.

Observatory, Peninsula, Windsor, N.S. Wales:
1902 *February* 24.

Erratum in Double Star Measures, Monthly Notices, vol. lxi. p. 504:

Opposite to ref. No. 55 and under "No. of Obs." *for* 10–6 *read* 10–10.

The Parallax and Proper Motion of Nova Persei, from Photographs taken at the Royal Observatory, Greenwich.

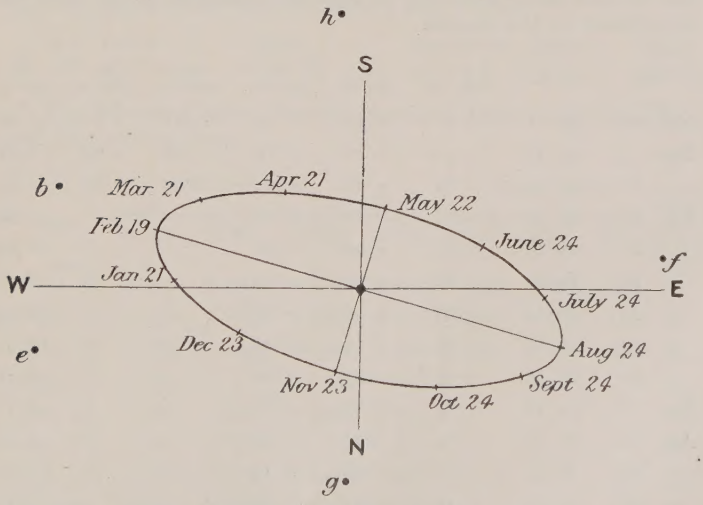
(*Communicated by the Astronomer Royal.*)

Photographs of Nova *Persei* have been taken with the Astrographic Equatorial at intervals from 1901 February 28, the earliest date on which it could be observed at Greenwich, to the present time. Twenty of these photographs have been measured for the determination of parallax and proper motion in R.A. and six for the proper motion in declination. The distances of the Nova from the three stars *e*, *b*, *f* were measured for the displacement in R.A., and *g* and *h* for that in Dec.

The positions and magnitudes of these reference stars are :—

Mag.	No. in B.D.	B.A. 1900.	Dec. 1900.	Distance and Pos. Angle from Nova.
	°	h m s	° ′ ″	′ °
e 9·1	43, 731	3 21 34·92	43 38 39·2	31 280
b 7·7	43, 732	3 21 46·67	43 24 21·3	30 252
f 9·2	43, 757	3 27 3·65	43 30 45·2	29 96
g 8·8	43, 740	3 24 17·62	43 51 57·9	18 356
h 9·2	42, 773	3 24 10·66	43 7 24·2	26 186

The right ascensions and declination for 1900·0 are taken from Mr. Bellamy's paper in the *Monthly Notices*, vol. lxi. March.



The positions of these stars relatively to the Nova are shown on the diagram, and for convenience the form and position of the parallactic ellipse are given, but necessarily on a greatly magnified scale.

The measurement was made by comparison with a glass scale divided to millimetres : two microscopes are carried on the same slide ; one of these is set on a division of the scale by a screw moving the slide, and the image of the star is bisected by the micrometer of the second microscope. The screw of this micrometer has three revolutions to the millimetre. For bisecting the star image parallel wires are used, which can be set at any distance apart. For the early photographs where the image of the Nova was very large the wires were set at 0·50 rev. (= 10″) apart, for the later photographs 0·20 rev. (= 4″). In making the measures the following precautions were taken :

(i.) Each distance was measured in a direct and reversed position of the plate.

(ii.) The same divisions of the scale were used for all the photographs.

(iii.) Each image was bisected twice, the right-hand microscope being set on consecutive divisions of the scale. Each pair of bisections thus furnishes a determination of the runs of the micrometer.

(iv.) The same parts of the screw were used on all the photographs.

(v.) The photographs were measured in duplicate by Mr. Dyson and Mr. Davidson.

The following table gives the measured distances (corrected for refraction and aberration) *ne*, *nb*, *nf*, *ng*, *nh*, and *ef*, the last named being measured to test the constancy of the scale and as a check on the results.

Date.	Z.D.	*ne*. 1862″·57.	*nb*. 1803″·68.	*nf*. 1742″·61.	*ng*. 1098″·14.	*nh*. 1585″·44.	*ef*. 3603″·32.
1901.	° ′	″	″	″	″	″	″
Feb. 28	52 1	+·27	+·24	−·11	−·22	+·10	+·08
Mar. 3	33 53	+·40	+·10	−·18	−·22	+·07	+·07
12	39 9	−·04	−·18	+·01	+·09	+·01	−·02
Apr. 18	69 30	−·14	−·07	+·26			+·28
21	66 13	+·35	+·42	−·32			+·19
23	64 40	−·04	+·34	+·03			−·16
25	66 41	+·25	+·40	−·07			+·14
27	68 10	+·24	+·13	−·25			+·01
30	68 55	+·07	+·23	+·10			+·21
May 8	74 10	+·15	+·03	−·07			+·11
Aug. 10	34 25	−·34	−·25	+·52			+·20
23	57 33	−·13	−·08	+·19			·00
26	55 25	−·12	−·24	+·18			+·15
Sept. 21	42 10	−·33	−·36	+·06			−·47
Dec. 6	17 9	−·14	−·22	+·06			−·08
1902.							
Jan. 6	37 50	−·13	−·17	−·12			−·15

Date.	Z.D.	*ne.* 1862″·57.	*nb.* 1803″·68.	*nf.* 1742″·61.	*ng.* 1098″·14.	*nh.* 1585″·44.	*ef.* 3603″·32.
1901.	° ′	″	″	″	″	″	″
Jan. 24	29 3	+·21	+·13	−·16			·00
Feb. 9	21 45	+·09	−·04	−·03	+·10	−·11	−·06
9	24 0	·00	+·02	+·03	+·19	·00	·00
12	26 29	−·62	−·43	−·15	+·06	−·08	−·49

In the above table it should be noticed that *ne* and *nb* are on the same side of the Nova, in position angles only 28° apart, while *nf* is on the opposite side, so that if the Nova has any motion in right ascension *nf* should increase as *ne* and *nb* decrease. Similarly *ng* and *nb* are in nearly opposite directions north and south. The changes of scale indicated by the measures of *ef* are small, and in some cases the figures only represent the accidental error of measurement. The two days, September 21 and February 12, seem abnormal, and the photographs are on this account open to some suspicion. They have been carefully examined, and nothing has been found wrong in the measurement or in the photographs themselves.

In forming the following table the scale of each photograph has been corrected so as to make *ef* equal to its mean value, 3603″·32. The right ascension is determined from the three stars *e*, *b*, *f*, and the declination from *ng* and *nh*.

The right ascension deduced from the three stars *e*, *b*, *f* and the declination from the two stars *g* and *h* are :

R.A. 1900·0.	Epoch.	Declination 1900·0.	Epoch.
$3^h\ 24^m\ 24^s·199$	1901·58	43° 33′ 42″·41	1901·64

The following table gives the separate determinations of R.A. and Dec. of the Nova :

Date.	Seconds of R.A. From *ne.* 24ˢ·203.	From *nb.* 24ˢ·164.	From *nf.* 24ˢ·230.	Mean. 24ˢ·199.	Seconds of Dec. From *ng.* 42″·02.	From *nh.* 42″·82.	Mean. 42″·41.	Pos. of Instrument with respect to Pier.
1901.	s	s	s	s	″	″	″	
Feb. 28	+·021	+·017	+·014	+·017	+·24	+·06	+·15	E.
Mar. 3	+·032	+·006	+·019	+·018	+·24	+·04	+·14	E.
Mar. 12	−·003	−·015	−·002	−·007	−·09	·00	−·04	E.
Apr. 18	·025	−·018	−·011	−·018	...	...	...	E.
Apr. 21	+·023	+·029	+·037	+·030	...	...	...	E.
Apr. 23	+·004	+·038	−·010	+·011	...	...	...	E.
Apr. 25	+·016	+·029	+·013	+·019	...	...	...	E.
Apr. 27	+·021	+·011	+·023	+·018	...	...	...	E.
Apr. 30	−·004	+·011	·000	+·002	...	...	...	E.
May 8	+·008	−·002	+·011	+·006	...	...	...	E.
Aug. 10	−·040	−·030	−·038	(−·036)	...	...	...	W.
Aug. 23	−·012	−·007	−·017	−·012	...	...	...	W.

Date.	Seconds of R.A. From *ne.* 24ˢ·203.	From *nb.* 24ˢ·164.	From *nf.* 24ˢ·230.	Mean. 24ˢ·199.	Seconds of Dec. From *ng.* 42″·02.	From *nh.* 42″·82.	Mean. 42″·41.	Pos. of Instrument with respect to Pier.
1901.	s	s	s	s	″	″	″	
Aug. 26	−·018	−·027	−·010	−·019	...	...	...	W.
Sept. 21	−·008	−·011	−·026	−·015*	...	...	...	W.
Dec. 6	−·009	−·016	−·009	−·013	...	...	...	W.
1902.								
Jan. 6	−·005	−·009	+·005	−·003	...	...	...	E.
Jan. 24	+·019	+·011	+·014	+·015	...	...	...	E.
Feb. 9	+·011	−·001	−·000	+·003	−·12	−·08	−·10	E.
,,	·000	+·002	−·003	·000	−·19	·00	−·09	E.
Feb. 12	−·034	−·017	−·008	−·020*	−·22	−·15	−·04*	E.

(1ˢ in R.A. = 10″·85 in arc of a great circle.)

The measures made on August 10 are bracketed, as it was found on examination of the images that the dome had cut off a small portion of the object-glass on one side. Half weight has been given to the measures marked * on account of the difference of scale-value which these photographs show.

Using the ten plates from February 28 to May 8 and the five from 1902 January 6 to February 12 we obtain −ˢ·009 for the proper motion in R.A. Similarly the proper motion in declination = −0″·20. Owing to the difficulties arising from the size of the image of the Nova in the early photographs, these results are only provisional, but they show that the Nova has not a very large proper motion.

The measures of these photographs were undertaken with the view of determining the parallax. The parallactic displacement in R.A. corresponding to a parallax of 0″·1 is approximately −ˢ·009 at the end of February and +ˢ·009 in July and August. The actual displacements found at these times are in the opposite direction. Examination of the above table shows that the parallax of the Nova is probably considerably less than 0″·1.

The positive residuals in April may possibly be due to the low altitude of the star, and it may be noticed that the negative values in August are obtained with the instrument on the W. of the pier, while the rest are on the E. of the pier.

Erratum in Annual Report, 1902.

Page 265, line 8, *for* " temporary computer, Mr. Henderson. The Catalogue for 1840 is," *read* " temporary computer. The Henderson Catalogue for 1840 is."